

Milestones in Green Transition and Climate Compatible Development in Eastern and Southern Africa



Editors

**Truphena E. Mukuna
and
Christopher A. Shisanya**



**Organisation for Social Science Research
in Eastern and Southern Africa (OSSREA)**

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Caption: The Photo on front cover shows solar panels installed in Northern Cape Province of South Africa, as one of the green energy technologies that factor into green transition and climate Compatible development

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Acronyms

AAU	Association of African Universities
ACP-EU	African, Caribbean Pacific-European Union
ACTS	African Centre for Technology Studies
ADB	Asian Development Bank
ADF	Augmented Dickey-Fuller test
AfDB	African Development Bank
AIDS	Acquired Immune Deficiency Syndrome
AMCEN	African Ministerial Conference on Environment
ASALs	Arid and Semiarid Lands
ASDS	Agricultural Sector Development Strategy
ASDS	Agricultural Sector Development Strategy
ATMs	Automatic Transfer Machines
ATPS	African Technology Policy Studies Network
BRT	Bus Rapid Transit System
CA	Conservation Agriculture
CAADP	Comprehensive Africa Agriculture Development Programme
CBD	Central Business District
CCCU	Climate Change Coordination Unit (Kenya)
CCD	Climate compatible development
CCS	Climate Change Strategies
CCTV	Closed Circuit Television
CDKN	Climate and Development Knowledge Network
CDKN	Climate and Development Knowledge Network
CDM	Clean Development Mechanism
CEDAW	Convention for the Elimination of All forms of Discrimination Against Women
CFL	Compact Fluorescent Lighting
CFU	Carbon Finance Unit (Kenya)
CIRCLE	Climate Impact Research Capacity and Leadership Enhancement
CO ₂	Carbon dioxide gas
COMESA	Common Markets of Eastern and Southern Africa
COP	Conference of the Parties
CRS	Catholic Relief Services
CSA	Climate-Smart Agriculture
CSF	Community Social Forestry (Lesotho)
CSOs	Civil Society Organisations
DBSA	Development Bank of Southern Africa
DEA	Department of Environmental Affairs

DEA	Department of Environmental Affairs (South Africa)
DEDT	Department of Economic Development and Tourism (South Africa)
DESD	Decade of Education for Sustainable Development
DfID	Department for International Development
DME	Department of Minerals and Energy (South Africa)
DoE	Department of Energy (South Africa)
DRR	Disaster Risk Reduction
DTI	Department of Trade and Industry (South Africa)
EAC	East African Community
ECRs	Early Career Researchers
EEC	European Economic Community
EPACC	Ethiopian Plan of Adaptation for Climate Change
ECRs	Early-career Researchers
ESD	Education Sustainable Development
FANRPAN	Natural Resources Policy Analysis Network
FAO	Food and Agriculture Organisation of the United Nations
FBE	Free Basic Electricity (South Africa)
FDRE	Federal Democratic Republic of Ethiopia
GCF	Green Climate Fund
GDP	Gross Domestic Product
GHG	greenhouse gas emissions
GII	gender inequality index
GLOBE	Global Legislators Organisation for a Balanced Environment
GoK	Government of Kenya
GoM	Government of Malawi
GPS	Global Positioning System
GTP	Growth and Transformation Plan”
HESD	Higher Education for Sustainable Development
GUNi	Global University Network for Innovation
HEIs	Higher Education Institutions (HEIs)
HICs	high income countries
HIV	Human Immunodeficiency Virus
IAU	the International Association of Universities
IC	Initial Communications
IDB	Indian Development Bank
IDC	Industrial Development Corporation (South Africa)
IDPs	Integrated Development Plans (South Africa)
IDS	Institute of Development Studies (Sussex, U.K.)

IEA	International Energy Agency
IEIA	United States International Energy Information Administration
IFAD	International Fund for Agricultural Development
IGAs	Income-Generating Activities
IMCCC	Inter-Ministerial Committee on Climate Change
INEP	Integrated National Electrification Programme (South Africa)
IPAP	Industrial Policy Action Plan (South Africa)
IPCC	Intergovernmental Panel on Climate Change
IRPTN	Integrated Rapid Public Transport Networks
KCCWG	Kenya Climate Change Working Group
LAA	Land Administration Authority (Lesotho)
LCC	Life-Cycle Cost
LDCs	Least Developed Countries
LICs	Low Income Countries
LMICs	Lower Middle Income Countries
LTAS	Long-Term Adaptation Scenarios (South Africa)
LTMS	Long-Term Mitigation Scenarios (South Africa)
MAD	Mean Absolute Deviation
MADF	Machobane Agricultural Development Foundation (Lesotho)
MALF	Ministry of Agriculture Livestock and Fisheries (Kenya)
MAPE	Mean Absolute Percentage Error
MCB	marginal climate benefit
MDGs	Millennium Development Goals
MEMR	Ministry of Environment and Mineral Resources (Kenya)
MEWNR	Ministry of Environment Water and Natural Resources (Kenya)
MfCEA	Ministry for the Co-ordination of Environmental Affairs
MICA	Mountain Integrated Conservation Agriculture (Lesotho)
MICOA	Ministry for the Coordination of the Environmental Affairs (Mozambique)
MJ	Megajoules
MoA	Ministry of Agriculture
MoSE-DE	Ministry of State-Environment, Division of Environment
MoWLD	Ministry of Water and Livestock Development

MoWR-NMA	Ministry of Water Resources-National Meteorological Agency
MPB	Marginal Private Benefit
MRV	Monitoring, Reporting and Verification (Kenya)
MSB	Marginal Social Benefit
MSD	Mean Squared Deviation
NAMAs	Nationally Appropriate Mitigation Actions (Kenya)
NAPA	National Adaptation Programme of Action
NCCAP	National Climate Change Action Plan (Kenya)
NCCFP	National Climate Change Focal Point
NCCRS	National Climate Change Response Strategy (Kenya)
NDP	National Development Plan (South Africa)
NEB	Net Energy Balance
NECSA	South African Nuclear Energy Corporation
NEMA	National Environmental Management Authority (Kenya)
NEPAD	New Partnership for Africa's Development
NGP	New Growth Path
NPC	National Planning Commission (South Africa)
NREB	Net Renewable Energy Balance
NSSD	National Strategy for Sustainable Development (South Africa)
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Square method
OSSREA	Organisation for Social Science Research in Eastern and Southern Africa
PERI-PERI	Partners Enhancing Resilience for People Exposed to Risks
PTIS	Public Transport Infrastructure and Systems
RECs	Regional Economic Communities
REDD+	Reducing Emissions from Deforestation and Forest Degradation
RSA	Republic of South Africa
RSDA	Rural Self-Help Development Association (Lesotho)
SADC	Southern African Development Community
SANEDI	South African National Energy Development Institute
SARUA	Southern African Regional University Association
SCL	Send-a-Cow Lesotho (an NGO in Lesotho)
SDGs	Sustainable Development Goals
SEZ	Special Economic Zone (South Africa)
SNC	Second National Communication (Lesotho)

SSA	Sub-Saharan Africa
TVET	Technical Vocational Education and Training
UMICs	Upper Middle Income Countries
UN	United Nations
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention on Combating Desertification
UNCED	UN Conference on Environment and Development
UNDP	United Nations Development Programme
UNECA	The United Nations Economic Commission for Africa
UNECLAC	United Nations Economic Commission for Latin America and the Caribbean
UNEP	United Nations Environment Programme
UNEP	United Nations Environmental Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
VSLs	Village Savings and Loans
WCED	World Commission on Environment and Development
WVL	World Vision Lesotho

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INTRODUCTION

Theoretical Underpinnings of Climate Compatible Development and Green Growth in Selected Eastern and Southern African Countries

Truphena E. Mukuna

1. Introduction

1.1. The Context

It is widely recognised that climate change poses significant serious threats to sustained economic growth and agricultural development, poverty reduction, food security and political stability globally. Nowhere are these challenges more marked than in Africa where two-thirds of all available land is classified either as desert or dry land, in relation to which the Intergovernmental Panel on Climate Change (IPCC) (2013) has classified the continent as the most vulnerable to climate change variability. This situation is further aggravated by the interaction of multiple stresses occurring at various levels, compounded by low adaptive capacity of the people. Although, amidst these challenges, Africa has experienced tremendous economic growth over the past decade to the point that it has become one of the world's fastest growing regions, Odeku (2013) calls for concerted efforts to be made to ensure climate compatible governance of this growth. AMCEN, UNEP and Climate Analytics (2013) in The Africa Adaptation Gap Report confirm that Africa faces huge financial challenges in adaptation to climate change. The report posits that Africa is a "vulnerability hot spot" for the impacts of climate change. This was confirmed also in the World Bank's (2013) report *Turn down the Heat: Climate Extremes, Regional Impacts, and the Case for Resilience*, which focused on sub-Saharan Africa among three world regions. The adaptation challenge for Africa will be much larger if the emissions gap is not closed and mitigation beyond 2020 falls short, which likely implies a 4°C warmer world at the end of the century (AMCEN, UNEP and Climate Analytics 2013). Cognisant of this reality, most national policy documents do prioritise both adaptation and mitigation actions, with some framing these as resilient and low carbon development. However, a general framing is that adaptation should be the main priority in the countries' development goals, while at the same time embracing any developmental opportunities of cleaner energy and other low carbon technologies (SARUA 2014).

As the world went past the flagship COP 17 that took place in Durban, South Africa and the 20th anniversary of the Rio Convention (the UN Convention on Environment and Development), popularised as the Rio + 20 with its outcomes document "*The future We Want*", phrases such as the

‘green economy’, ‘climate financing’, ‘green growth’ as well as ‘inclusive and sustainable development’ have emerged. These new phrases are now shaping the discourse on development (International Policy Centre for Inclusive Growth IPC–IG, 2011). *The Future We Want*, the outcome of the Rio+20 Sustainable Development Summit, recognises the vital role for green growth strategies, which “*should contribute to eradicating poverty as well as sustained economic growth, enhancing social inclusion, improving human welfare and creating opportunities for employment and decent work for all, while maintaining the healthy functioning of the earth’s ecosystems*” (UNCSD 2012). Green growth strategies are, in part, a response to the serious risk now posed to the global economy by increasing pressure on the environment. Transforming economic activity to improve efficiency and management of natural resources is vital to the stability and sustainability of the future economy — a green economy. Development decisions, if they are to be effective over a long period, need to include climate-related risks and opportunities. To this end, climate compatible development is essential for development and poverty reduction in Africa.

Sustainable development has been the overarching goal of the international community since the UN Conference on Environment and Development (UNCED) in 1992. Amongst numerous commitments, the Conference called upon governments to develop national strategies for sustainable development, incorporating policy measures outlined in the Rio Declaration and Agenda 21. Despite the efforts of many governments around the world to implement such strategies as well as international cooperation to support national governments, there are continuing concerns over global economic and environmental developments in many countries (UNDESA 2012). There is a growing international focus on how to support more integrated approaches to addressing climate change in ways that capture synergies and minimise the trade-offs between climate change mitigation, adaptation and development. Increasingly, governments are identifying climate change as a development and economic issue and integrating climate resilience and low carbon development into planning (McDonnell and McNamara 2014).

Despite the growing international interest in climate compatible development, negotiations among member states within the UNFCCC, Rio + 20, and Agenda 21, several challenges have emerged and slowed down the implementation of these protocols. Nations are seeking effective ways to address this crisis and green economy has been proposed as a means for analysing renewed national policy development, international co-operation and support for sustainable development (Stakeholder Forum for a Sustainable Future 2012). There is a great focus for both international and national responses to climate change, with much policy attention focused on defining the parameters of climate finance and its effective delivery. Climate compatible development remains an emerging concept which has yet to be fully articulated and tested in practice. There has been considerable discussion around whether and how mitigation and adaptation can be combined (Klein *et al.* 2007a), how more integrated development

frameworks may be developed (e.g. Halsnaes and Verhagen 2007), and how barriers can be overcome and synergies utilised between the two in a developing country context (Dodman, Ayers and Huq 2009). At a sectoral level, considerable attention is paid to the potential for triple wins in agriculture (FAO 2010). However, there is a lack of empirical and theoretical evidence to understand how climate compatible development can be planned and implemented across a diverse set of contexts (Ecofys and IDS 2011). In most countries of Sub-Saharan Africa, climate change is a peripheral ‘add on’ in the minds of economic finance ministers, who are presumed to have a pro-growth development mind-set. Policy makers lack the technical capacity required to assess climate risks and opportunities. Additionally, in as much as there is growing awareness of the need for resilience, a general case for low carbon has not been well made (Bickersteth 2012).

Much of Africa’s economic growth is dependent on climate-sensitive sectors such as agriculture, forestry and fisheries, as are the livelihood prospects of a majority of the region’s population. Sub-Saharan Africa is a rapidly developing region with a population of about 900 million, and wide ecological climatic and cultural diversity. At present, six of the ten fastest growing economies in the world are in Africa (SARUA 2014). Growth in these economies started from a relatively low base so the current rate of economic growth needs to be seen against a background of three decades of poor development performance, conflict and economic marginalisation. Some of these problems remain. However, there are hopeful signs that a number of countries are turning a corner for the better. Many national governments are striving to tackle climate change by passing climate legislation, setting national targets and developing climate action plans (Stakeholder Forum for a Sustainable Future 2012).

In its 2013 report, the Global Legislators Organisation for a Balanced Environment (GLOBE International) recorded 33 countries that had enacted national climate legislation, of which 21 are not members of the Organisation for Economic Co-operation and Development (OECD), and this trend continued in 2014 (GLOBE International 2013). Climate policies that deliver ‘triple wins’, i.e. action on climate change adaptation, mitigation or development, and that produce additional climate change and development benefits are critical (GDPRD 2011). Nations are at crossroads as to whether to implement climate compatible development or concentrate on the reduction of poverty, inclusive growth, jobs creation and improvement of livelihoods. There is no or limited data in most SSA countries on climate compatible development; so, there appears to be baseless case studies. There is also lack of national climate change databases to house climate-related information across the range of sectors and disciplines (SARUA 2014; UN 2013; Anton *et al.* 2014). However, many countries have made efforts towards climate compatible development through policy options, but successful combination of social, economic and

environmental co-benefits in policy and practice has remained more elusive.

Over the past several years, countries, regions, and cities around the world have designed and tested a range of policies that aim, simultaneously, to deliver economic development, poverty reduction, environmental protection, and action on climate change. Decision-makers together with the millions of business strategists, project managers, civil servants, community organisers, and others responsible for delivering these policies have built up an important body of experience. The extent to which the implementing nations have achieved climate compatible development, challenges and prospects has not been comprehensively researched and documented. All these need to be documented as milestones in climate compatible development in Eastern and Southern Africa. The scale of the world's environmental challenge means there is no time to waste in sharing these valuable lessons within and across borders.

1.2. Rationale for the Book

This anthology is a product of a call from OSSREA to collate evidence-based researches in a book in a bid to assess how far countries in eastern and southern Africa are implementing the UNFCCC, Rio+20, Agenda 21 and other global and Africa-wide decisions concerning the need to address climate change. This will contribute to post-2015 development agenda for sustainable development goals (SDGs), in which climate change and disaster risk reduction will be priority areas of focus. We hope this book will serve as a valuable tool for experts, advisers and policymakers in pursuing effective green growth policies and practices and achieving climate compatible development and in doing so inspire readers to choose a more sustainable pathway for humanity. It will also help in looking at climate change as both a challenge and opportunity for development. Further, this book aims at stimulating more research in climate compatible development and climate financing which have put most countries at crossroads.

2. Conceptualisation of Key Terms

2.1. Climate-Compatible Development

Climate compatible development (CCD) is low carbon, climate resilient development concept. The concept has been developed in recognition of the urgent need for adaptation, given current climate variability and the severity of projected climate impacts that will affect the region; and the need to reduce emissions as rapidly as possible to avoid more catastrophic climate change in the future. Thus, while CCD can be framed in different ways, given nationally and locally specific development trajectories, it does require that current and future climate risks are mainstreamed into development, and that both adaptation and mitigation are integral goals of development (see Figure 1, adapted from Mitchell and Maxwell 2010). Climate compatible development builds on the long established concepts of

adaptation and mitigation, as well as the newer concepts of climate resilient development and low carbon.

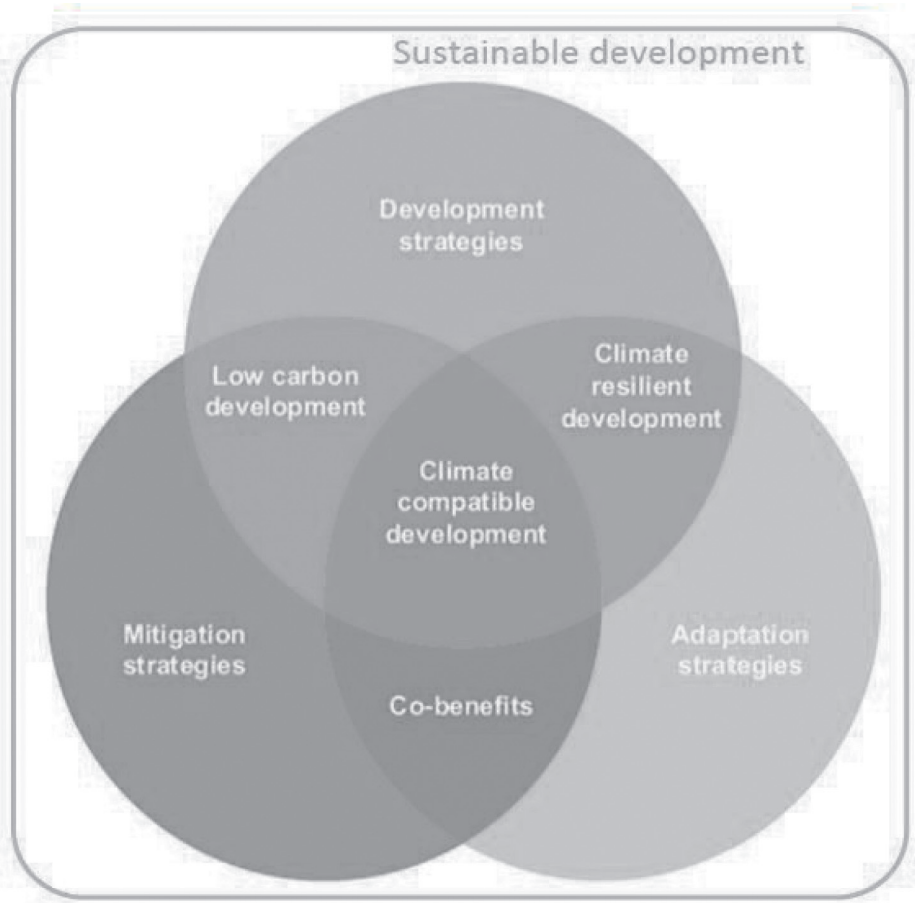


Figure 1. Conceptual Framework for Climate Compatible Development
SOURCE: Taken from Mitchell and Maxwell (2010, 2)

Climate compatible development means reducing poverty and securing human development in a way which reduces the extent of climate change, and also helps societies to adapt to inevitable change. CCD is defined as “development that minimises the harm caused by climate impacts, while maximising the many human development opportunities presented by low emissions, more resilient future” (Mitchell and Maxwell, 2010). It puts human development and poverty alleviation at the heart of adaptation and mitigation (Zadek 2009). As such, CCD affects every sector of the economy and any program and policy should take this into account.

Climate compatible development focuses on a combination of climate resilience, emissions efficient growth and poverty alleviation all within a central focus on development (Bickersteth 2012). The practical implementation of climate compatible development results in trade-offs that balance the need for climate change adaptation, mitigation and a country's development agenda.

As a policy goal, CCD describes the conditions that allow a community or nation to bounce back from and prosper in the face of climate stress. CCD policies aim to deliver green growth while at the same time supporting people's ability to adapt to climate change. To better understand the potential for synergies between and among adaptation, mitigation and development, we first conceptualise adaptation and mitigation. Adaptation is defined as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (Smit *et al.* 2001, 881). Climate adaptation tends to be delivered through four main routes: reductions in existing vulnerabilities to past and present stressors, building adaptive capacity, risk management to address current and future risks, or building long-term resilience to climate change (Ensor and Berger 2009; McGray *et al.* 2007). Adaptations most often occur locally and reactively in response to real or perceived climate threats (Adger, Nelson, and Brown. 2007). At the national level, adaptation is frequently driven by government action (Tompkins *et al.* 2010), and most often focuses on reducing existing vulnerabilities or building adaptive capacity (McGray *et al.* 2007). There is significant research on individual aspects of adaptation in developing countries, specifically vulnerability reduction and disaster risk reduction, but far less on building adaptive capacity and building longer term resilience (Berrang-Ford *et al.* 2011).

Mitigation activities can be broadly grouped into five main areas: efficient use of energy (i.e. reducing system waste); use of renewable energies (such as solar energy, bio-fuels, wind energy, ocean thermal exchange); carbon sequestration through enhanced sinks (e.g. reforestation, afforestation); reduced sources of emissions through land use management, and macro-engineered carbon capture and storage (Boyd and Tompkins 2010). Research has identified that most emission reductions can occur in those sectors where these four mitigation activities are most feasible, i.e. energy supply, industry, buildings, transport, agriculture, forestry, and waste management (Metz *et al.* 2007). Research on mitigation has focused largely on developed countries, with the exception of research into tropical forestry — where the relative importance of mostly developing country forests as carbon sinks has been debated (Van der Werf *et al.* 2009).

2.2. Development

Development can be defined in a variety of ways. Traditionally it has been measured in terms of economic growth, though now it includes a much broader range of dimensions/elements, such as the concepts of human

development and well-being. Chambers (2004, 2) argues that the two main components of development are that it is normative and involving change; thus the most basic definition of development would be “good change”. Low carbon development sits at the interface between mitigation and development, and aims at promoting development while reducing emissions. It can be described simply as “using less carbon for growth”, and may be achieved by four key strategies (DFID 2009):

1. Moving to low carbon energy sources and energy efficiency;
2. Protecting natural resources that absorb and store carbon (forests and land);
3. Developing low carbon technologies and business models; and
4. Implementing policies and incentives which discourage carbon-intensive practices and behaviours.

Similarly, climate resilient development has gained popularity over recent years. Defined as “development processes that safeguard development from climate impacts” (Mitchell and Maxwell 2010, 1). It points to the need for ensuring that development is considering the range of potential risks as well as opportunities arising from climate change. CCD is a very young term, and it is still unclear what climate compatible development pathways may look like in practice. Thus, while CCD can be framed in different ways, given nationally and locally specific development trajectories, it does require that current and future climate risks are mainstreamed into development, and that both adaptation and mitigation are integral goals of development.

2.3. Green Economy

UNEP defines a green economy as one that results in “improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities” (UNEP 2010). A green economy is low-carbon, resource efficient, and socially inclusive. In a green economy, growth in income and employment are driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services. The key aim for a transition to a green economy is to enable economic growth and investment while increasing environmental quality and social inclusiveness. Critical to attaining such an objective is to create the conditions for public and private investments to incorporate broader environmental and social criteria. In addition, the main indicators of economic performance, such as growth in Gross Domestic Product (GDP) need to be adjusted to account for pollution, resource depletion, decline in ecosystem services, and the distributional consequences of natural capital loss to the poor. Mounting evidence also suggests that transitioning to a green economy has sound economic and social justification. There is a

strong case emerging for a redoubling of efforts by both governments as well as the private sector to engage in such an economic transformation.

A transition to a green economy can assist in overcoming the contribution that population growth makes to the depletion of scarce natural resources. The world's least developed countries (LDCs) are more seriously affected by environmental degradation than most developing countries (UNCTAD 2010), thus have much to gain from the transition to a green economy. Most economic development and growth strategies encourage rapid accumulation of physical, financial and human capital, but at the expense of excessive depletion and degradation of natural capital, which includes natural resources and ecosystems. By depleting the world's stock of natural wealth, often irreversibly, this pattern of development and growth has had a detrimental impact on the wellbeing of current generations and presents tremendous risks and challenges for the future. The concept of a green economy does not replace sustainable development; but there is a growing recognition that achieving sustainability rests almost entirely on getting the economy right. The UN General Assembly Rio+20, celebrated the 20th anniversary of the first Rio Earth Summit that was held in 1992, whose agenda items were, "Green Economy in the Context of Sustainable Development and Poverty Eradication", and "International Framework for Sustainable Development". And it further advanced the importance of pursuing green economy in practice.

2.4. Green Growth

Governments today face challenges in advancing economic and social development in light of resource constraints and risks posed by climate change and environmental degradation. Green growth is now a necessity rather than a choice and is fast becoming an attractive opportunity for countries around the world to achieve poverty reduction, environmental protection, resource efficiency and economic growth in an integrated way. Green growth strategies generate policies and programs that deliver these goals, simultaneously accelerating investment in resource-efficient technologies and new industries, while managing costs and risks to domestic taxpayers, businesses, communities and consumers (UNCSD 2012). Recent studies from United Nations Environmental Programme (UNEP), Organisation for Economic Co-operation and Development (OECD), World Bank, United Nations Development Programme (UNDP), United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), United Nations Economic Commission for Latin America and the Caribbean (UNECLAC), Asian Development Bank (ADB), African Development Bank (AfDB), Indian Development Bank (IDB) and others have shaped our understanding of green growth principles for both developing and developed countries. Yet, there remains an unfulfilled demand for a practical assessment of effective approaches and lessons on the design and implementation of green growth. Transforming economic activity to improve efficiency and management of natural resources is vital

to the stability and sustainability of the future economy – a green economy; so is reducing environmental liabilities and risks critical as well.

2.5. Resilience

Resilience, borrowing heavily from the field of ecology, is often defined as the ability of a system (e.g. a household or a community) to maintain its core functions in times of stress, shocks, disturbances and the like. (Adger *et. al* 2005). Building resilience in the context of poverty must, at least in significant part, involve reduction of poverty and inequality. In other words, livelihood strengthening should be an integral part of promoting resilience in such contexts. Adaptation is a critical component of resilience (FAO 2011). Many poor and vulnerable populations will likely experience increasingly severe shocks and stresses in the future (IPCC 2011). Developing the capacity of relevant national and local level duty bearers (e.g. district level state institutions) to provide support in times of extreme crisis is also an integral part of building resilience.

The ability for a community to represent itself to decision makers is a critical aspect of resilience (Oxfam 2013). Shoddy infrastructure and degraded natural resources and ecosystems are further both less able to absorb shocks (Dodman, Ayers and Huq 2009) and may rule out critical adaptation opportunities, e.g. through restricting access to markets or limiting the production of new commodities. Hence, developing resilient physical infrastructure, ensuring ecosystem protection, and promoting sustainable natural resource management practices are also integral to resilience promotion.

From the above, it is clear that building resilience does not simply mean doing one thing, such as strengthening livelihoods; rather, it is a multifaceted, multidimensional construct that must be understood and tackled from various angles. It is recognised that healthy ecosystems are likely better able to cope/adjust to climatic shocks/change than are those that are relatively more degraded. Let us assume, with all other things being equal that households whose livelihoods are dependent on healthy ecosystems will be in a better position to adjust to shocks and change than those that are not. The presence of appropriate infrastructure (e.g. pit latrines and roads) that is resilient to shocks and stresses (e.g. flooding) is also important: if critical infrastructure no longer functions or collapses in times of shocks and stress, the livelihoods and/or wellbeing of community members can be negatively affected. Adaptation opportunities may also be restricted.

However, in most, if not all cases, it is necessary to look beyond the household level when examining resilience. Indeed, it is reasonable to assume that households are likely better able to successfully adjust to shocks, disturbances, and change when they are part of larger coordinated efforts at the community level and beyond. The social and institutional capability dimension, in particular, is concerned with the effectiveness of

formal and informal institutions in reducing risk, supporting positive adaptation, and ensuring equitable access to essential services in times of crisis. In the absence of this capability, we can assume that local and non-local duty bearers will be less effective in fulfilling their responsibilities in supporting community members to reduce risk and/or successfully adapt. Critically, how well women and men at risk or suffering a shock can claim their rights from these institutions, determines their resilience. Resilience is not a fixed end state, but is a dynamic set of conditions and processes.

2.6. Sustainable Development

The Bruntland Commission (The World Commission on Environment and Development—WCED) defines sustainable development in ‘Our Common Future’ report (WCED 1987, 8), as “*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*”. This definition has been highly influential in shaping international environmental and development policy, since the Rio Earth Summit in 1992, where Agenda 21 was put forward as a global development plan for aligning goals of economic development with social and environmental sustainability. Early discussions on sustainable development tended to focus on the triple bottom line concepts of environment, economy and society separately. More recent discussions on sustainable development foreground the need for ‘strong sustainability’, in which society, economy and environment are seen as interacting in an inter-related, nested system. The concept of sustainable development, as used widely today, emphasises that everything in the world is connected through space, time and quality of life, and thus necessitates a systems approach to understanding and solving interlinked social, environmental and economic problems (SARUA 2014). With the SDGs now approved to guide the post-2015 global development agenda, the concept of CCD highlights the necessity of integrating current and future climate risks into development planning and practice, in the ongoing goal of achieving sustainable development.

This anthology comprises nine chapters that capture climate compatible development in various sectors of the economy, namely, agriculture, water, transport, energy, finance, and education. In a nutshell, however, this book does not cover all sectors of the economy in climate compatible development as envisaged by OSSREA. Among the missing sectors in the book are: fisheries, forestry manufacturing industry, waste management, building and construction, urbanisation, tourism, sustainable natural resources management, the mining sector, disaster risk management and resilience in ongoing development activities, capacity building in climate compatible development and entrepreneurial education; social protection for vulnerable groups in economic development zones; technology innovation, both indigenous and scientific knowledge, and transfer for climate-compatible development.

In this book, three chapters address climate compatible development in the agricultural sector. Agriculture is a major occupational sector in many developing countries and is an important source of income for the poor. Agriculture also has tremendous potential to alleviate poverty with a large proportion of the rural population in developing countries employed in agriculture. World Bank (2010) show agricultural value-addition at 3 per cent of the world's GDP, with 25 per cent for low income countries (LICs), 14 per cent for lower middle income countries (LMICs), 6 per cent for upper middle income countries (UMICs) and 1 per cent for high income countries (HICs). Approximately 2.6 billion people rely on agricultural production systems — farming, pastoralism, forestry and fisheries for their livelihoods (FAOSTAT 2005). In Africa, governments publicly committed to the Maputo Declaration of 2000 to spending 10 per cent of their GDP on agriculture, including rural infrastructure spending (UNESC ECA 2007). However, only eight countries had reached the agreed level by 2009 (CAADP 2009). The result of this long-term neglect of the agriculture sector in developing countries is that rural poverty rates have consistently exceeded those in urban areas, with more than 75 per cent of the world's most impoverished people living in rural areas, and many seeking ways to migrate to cities (IFAD 2003).

The first chapter by Professor Christopher Shisanya starts us off by exploring the mainstreaming of climate change adaptation in agriculture through a process dubbed 'climate-proofing', which is essentially concerned with protecting agricultural development investments and outcomes from the impacts of climate change. In this chapter on '*Mainstreaming Climate Adaptation into Agricultural Planning and Development in Kenya*', Shisanya explains how the Kenya government has made tremendous milestones in mainstreaming climate change adaptation in agriculture through its blue print documents of National Climate Change Response Strategy (NCCRS) and the National Climate Change Action Plan (NCCAP). He reports that the agriculture sector is one of the economic sectors in Kenya most vulnerable to climate change largely due to the increasing temperatures, changing rainfall patterns and extreme weather events. Some crops are expected to experience more favourable growing conditions as a result of climate change, whereas others will find future climatic conditions intolerable. The main objective of his study was to examine the extent to which the government of Kenya has mainstreamed adaptation to climate change in agricultural planning and development. To achieve this, he did a comprehensive review of relevant literature on the subject and employed content analysis as the analytical tool. The Action Adaptation theory guided the study. Shisanya recommends that for the Kenyan government to maximise benefits, a comprehensive institutional and mainstreaming framework, with defined roles and responsibilities is needed to be in place. Such a framework would capture the need to respond to climate change in the context of the devolved government system in Kenya. This critical analysis of the agricultural policies and their

integration into climate change provides readers with an illuminating account of the progress made in spite of several challenges. In focusing on the planning and mainstreaming of climate change into agricultural development, Shisanya touches on the fulcrum of climate compatible development in the agricultural sector in Kenya.

Patric Gwimbi's chapter "*Climate-Smart Agriculture in Lesotho: Some initiatives and perspectives*" takes us through climate-smart agriculture (CSA) in Lesotho. This chapter assesses CSA initiatives in Lesotho in terms of policy and implementation. Using desk review of various agricultural policies in Lesotho, Gwimbi reports that, in general, CSA policy intents exist in Lesotho. Conservation agriculture, homestead gardens and Machobane farming system are driven by the agricultural policy and supported by development partners. He found out that CSA programmes are, however, not sufficiently up-scaled nationally beyond those supported by donors. Additionally, Gender disparities in the national constitution restrict women to secondary land rights, meaning that they hold these rights through male family members, although improvements in sectoral policies are acknowledged. Gwimbi asserts that sectoral policies are still undermined by some clauses in the national constitution. He notes that while CSA can improve crop yields at household level, inputs and labour constraints remain a major limit to its wide adoption in the absence of external support. He is optimistic that the presence of some successful CSA initiatives suggests that opportunities exist. He, therefore, recommends that responses to climate change need to include fundamental changes to policies that constrain women participation in climate smart agriculture initiatives. For Lesotho to adopt climate-compatible agriculture, Gwimbi sees government partnership with development partners as an important component of CSA strategies.

Nwachukwu Ifeanyi Nyabuto and Shisanya Allan Christopher present a very insightful comparison on agricultural productivity in two East African Countries: Kenya and Uganda. In this chapter entitled "*Effects of Climate Change on Agricultural Productivity across East African Countries: Comparative Evidence from Kenya and Uganda*", the authors have used systematic analysis to show how climate change has affected agricultural productivity of cassava and maize over the years from 1970 to 2010. Using statistics from FAO, they assessed the changes in major climate variables in the region over the study period; determined the growth rate of productivity among the commodities; estimated the influence of climate variables on productivity of the commodities and deduced policy implications from the findings. Results showed that precipitation patterns in Kenya and Uganda showed high amplitude decadal variability, though more diverse in the former, with the forecast showing a slightly upward trend. In temperature, the inter-annual variability observed in Kenya was wide with a forecast of a steep rise up to 2010 while Uganda posted a continuous rise all through. The carbon dioxide emission increased in both countries with slight irregularity and showed a huge promise of future upward trend.

In terms of productivity, the log quadratic trend equation showed that maize experienced deceleration in Uganda while Kenya recorded acceleration within the period. However, the productivity of cassava in Uganda and Kenya stagnated with varying degrees of compound growth rate among other results. The poor and uneven distribution of precipitation in Kenya had already taken a heavy toll on the capacity of the country to feed her ever teeming population. With the prediction of marginal increase in precipitation, the performance of maize in the coming years may be adversely affected in Kenya. The effect may likely trigger reduced productivity of the crop and/or increase in the price while consumers may be faced with the option of resorting to substitutes. Similar irregularity of precipitation was observed in Uganda but with an anticipatory slight decrease in the forecast trend. This situation is expected to initiate production uncertainty. However, cassava, which is drought-resistant may not be adversely affected.

The transport sector is critical as far as climate change is concerned. This sector of the economy is central to the lives of citizens across the world, yet the current patterns of transport, dictated mainly by fossil-fuel-driven motor vehicles, generate a range of environmental, social, and economic costs. It is estimated, for example, that transport is responsible for nearly a quarter of global energy-related carbon dioxide (CO₂). There is a growing consensus on the need for more sustainable patterns of transport activity but investment patterns are still heavily skewed towards supporting the “motorisation” model of development.

Muchaiteyi Togo in her chapter on ‘*Adoption of green technologies in the public transport sector: The case of Rea Vaya BRT System, South Africa*’ explains how systems like *Rea Vaya*, which uses buses, have high potential of reducing emissions if there is modal shift from cars and taxis to buses. A double-decker bus can replace about 50 vehicles, making it a more sustainable mode compared to other modes. In addition, the carbon emissions per passenger kilometre are also very low when a bus transports more than 3 people compared to having the people drive their own cars. There is therefore high potential for climate change mitigation where Bus Rapid Transit System (BRT) systems replace smaller vehicles in urban mobility. Muchaiteyi highlights how the BRT system is a strategy of *avoiding* or reducing trips, *shifting* to more environmentally-friendly modes of transport and *improving* the efficiency of all modes of transport. This case study is a good innovation in Africa as far as climate compatible development is concerned; it is also in line with the routes to sustainable development. This is a positive step by the South African government to adapt to climate change while including all and developing other sectors of the economy too.

The current highly carbon-intensive energy system depends on a finite supply of fossil fuels that are getting harder and more expensive to extract, leading to concerns about national energy security in many countries. The

challenges are compounded by the need to provide clean and efficient energy services to the huge number of people without access. It is, thus, not sustainable in economic, social, and environmental terms. Furthermore, the current state of the energy sector leaves many countries exposed to large swings in oil import prices and also costs billions in public subsidies. Greening the energy sector will require improvements in energy efficiency and a much greater supply of energy services from renewable sources, both of which will lead to reducing greenhouse gas emissions (GHG) and other types of pollution. In most instances, improvement in energy efficiency has net economic benefits. Greening the sector also aims to end “energy poverty” for the estimated 1.4 billion people who currently lack access to electricity. Moreover, 2.7 billion people who are dependent on traditional biomass for cooking need healthier and more sustainable energy sources (IEA 2010a). Modern renewable energy offers considerable potential for enhancing energy security at global, national and local levels. In order to secure all these benefits, enabling policies are required to ensure that the investments are made for greening the energy sector. Chapters five and six, thus present about the energy sectors in Malawi and Mauritius.

Charity Chonde and Harriet Chiwaula in their chapter, *‘Rural Women’s Participation and Investment in Renewable Energy as a Low Carbon Adaptation Strategy: Evidence from the Sustainable Energy Project in Malawi’* presents a very interesting study on an organisation called *Concern Universal*, which implemented a 5-year Sustainable Energy Project in Balaka district, a drought-susceptible area which is typified by poverty and high levels of deforestation. It is affected by floods and windstorms that result in loss of livelihoods and housing. The project which ended in 2012, worked with 180,000 people in 321 villages to improve sustainable access to and use of energy. Project activities included the introduction of solar technologies, production and marketing of clean-fuel-efficient stoves called *Chitetezo mbaula*, afforestation and micro-businesses. In total, 24,000 fuel efficient cook stoves were sold and were in use by time the project terminated. This study set out to investigate whether rural women’s participation in sustainable energy project in southern Malawi enabled them to engage in activities that improved their livelihoods and the factors that influenced the rural women to invest in clean energy-efficient cooking stoves as a low carbon adaptation strategy.

They found out that the provision of energy-efficient low carbon cook stoves can mitigate negative impacts of climate change while promoting women’s empowerment, as the time that would have been used to collect fuel can now be used for other productive and economic activities (IUCN 2004; Gradl and Knobloch 2011). They also established that clean cook stoves and renewable energy in rural areas are examples of technology innovation processes that can be organised so as to advance the development and deployment of climate-compatible technologies to help meet the energy needs of the world’s poor and marginalised populations (Sagar 2013). Beneficiary women participated in various sustainable energy

project activities, namely, micro-businesses, VSLs, afforestation, community-based forest management and adult literacy programmes. This means that rural women participation in Sustainable Energy Project activities empowered them to engage in income-generating activities. Chonde and Chiwala recommended that women should be incentivised to promote their uptake of renewable energy technologies as a low carbon adaptation strategy. Furthermore, there is need to scrutinise household resource control and household structures when determining the capacity to invest in such low-carbon adaptation strategies. Since women possess little control over household resources, particularly land and income, the technologies should essentially signify that they benefit both men and women.

Riad Sultan in his Chapter entitled ' *Environmental and Economic Feasibility of Bioethanol Systems— Towards Climate Compatible Development* ' provides us with insights into the use of bio-ethanol as clean energy and a climate-compatible strategy. He gives a critical analysis of bio-ethanol as a renewable energy by defining the environmental and economic feasibility sets of bio-ethanol systems, the chapter develops a decision support framework to analyse the necessary and sufficient conditions under which bio-ethanol can be classified as a climate compatible development. From his analysis, Riad reports that bio-ethanol offers a vital opportunity for a CCD strategy. It is classified as a renewable energy with significant economic, energy security and climate benefits. The blend of bio-ethanol with gasoline is expected to reduce the dependency on fossil fuels and, according to the International Energy Agency (IEA 2010a), bio-ethanol has the potential to contribute up to 10% of world gasoline use by 2025 and 30% by 2050 (Amigun *et al.* 2008). Bio-ethanol enrichment has a major climate benefit by curbing greenhouse gases (GHGs), especially CO₂. According to Martines-Filho, Burnquist and Vian (2006), the blend of ethanol with gasoline at the rate of 10% (E10) may reduce GHGs by 12–19% and carbon monoxide by 30% compared to gasoline. Since the energy from bio-ethanol is generated from organic matter, that is, sugar cane, bio-ethanol is considered as a carbon-neutral energy. This is because the same amount of CO₂ is emitted when using bio-ethanol as was absorbed during the feedstock growth (Schubert and Blasch 2010). Its production is therefore 'sustainable' by the closure of the carbon cycle (Niven 2005). Riad therefore agrees that bio-ethanol is crucial for mitigating global climate change.

The author further sheds light on other advantages of using bio-ethanol. For instance, it reduces the need to use foreign exchange to purchase gasoline and this in turn may bring about multiple positive macroeconomic effects. It can also provide a new source of income to planters in the sugar industry who are struggling with competitive world market prices (Thomas and Kwong 2001). Developing countries including Zimbabwe, Kenya, Egypt, Zaire, Zambia, Sudan, Swaziland, and Mauritius could replace gasoline with ethanol using primarily sugar as feedstock (*ibid.*) and re-engineer their

sugar sector accordingly. The study eventually discusses the national and international policies which might be necessary to make bio-ethanol a climate compatible development. Riad concludes that it is not economically feasible to produce bio-ethanol unless the environmental benefits outweigh to make it a sustainable energy.

Chapter seven gives us a comprehensive and comparative analysis of water management as a natural resource in Ethiopia, Tanzania, and Mozambique. In climate-compatible development, the role of water in both maintaining biodiversity and ecosystem services and in providing water is recognised, valued, and paid for. The use of technologies that encourage efficient forms of recycling and reuse is encouraged. Yohannes Abera, in his chapter entitled '*Climate Compatible Development (CCD) in the water sector of Ethiopia, Mozambique and Tanzania*' reminds us that the adverse impacts of climate change on the water resources call for swift action into climate compatible development to avoid the unsustainable 'business-as-usual' approach to the development and management of water and related resources. The three countries, which have registered very high growth rates, need to make their development sustainable in the face of climate change. His analysis reveals that there have not been adequate stimulations for the directly water-related options as compared to the water-implied mitigation, since the latter is better financed than the former. Even the better funded mitigation actions are water-implied not water-intended. There has been little deliberate action to plan, monitor and evaluate mitigation actions in terms of how much water they have added into or subtracted from the systems. Further, the lack of water-audit for mitigation actions has obscured the contribution of mitigation actions to adaptation in the water sector. Such a lack of synergy between directly water-related adaptation and mitigation actions with water resource implications would result in a lopsided climate compatible development in the water sector. He asserts.

Theresa Moyo's chapter on '*Climate-Compatible Strategies in Planning and Investment in South Africa*' has addressed the planning and coordination of climate compatible development. This chapter is the heart of climate-compatible development because everything else revolves around finance and planning. Her findings reveal that while South Africa has been successful in developing and integrating climate compatible approaches into its planning and investment processes, the integration of developmental goals that underpin a CCD framework appear negligible. Furthermore, the implementation of climate response plans also remains quite limited. This is largely explained by the recent nature of most of the plans and also challenges of limited skills and capacity to implement CCD. The chapter recommends that the government should strengthen the institutional basis for CCD and also build the capacity in terms of knowledge and skills required for implementation.

The final chapter in this anthology is by Truphena Mukuna, whose narrative is on the importance of higher education in championing climate compatible development. In her chapter entitled '*Championing a Green Future through Higher Education: Initiatives of Selected Regional Research Organisations in Africa*', she underscores the important role of universities in facilitating and catalysing the green economy through research and capacity building. She presents examples of initiatives that have been implemented across Africa to build a critical mass of scholars in climate change, disaster risk reduction and social protection. She hails these initiatives (Climate Impact Research Capacity and Leadership Enhancement— CIRCLE, Southern African Regional University Association— SARUA, Partners Enhancing Resilience for People Exposed to Risks (with a focus on Universities PERI-PERI and the OSSREA INITIATIVE). The Moi University-OSSREA Hub of Climate Change, Disaster Risk Reduction and Social Protection for the multi-disciplinary, inter-disciplinary and intra-disciplinary approaches that they have in climate compatible development. These initiatives emphasise internationalisation of education, collaboration and networking among universities, strengthening of institutions for climate change research and research governance, career progression for early career researchers (ECRs), mentoring and supervision of the ECRs, and revision of the curriculum to align with national goals. These initiatives have embraced the transformative role of higher education towards sustainable development. She emphasises that tapping synergies between humanities and life sciences in terms of research on sustainable development is a crucial step in the attaining of their goals. In this age of harnessing efforts toward achieving sustainable development, universities are tasked with the role of increasing familiarity of climate compatible development concepts, principles and practices as well as accentuating areas of research and development.

Mukuna asserts that unless all universities and other institutions of higher learning vigorously swing into action, climate compatible development will take so long to be realised. The main challenge that Africa is having in understanding and facing the climate change challenge head-on is lack of capacity. The African countries realise that climate change affects them more than other continents and are making efforts to mainstream climate change in their development plans. Due to lack of capacity to implement the international and regional protocols on climate change, research universities should invigorate their research in climate compatible development.

Cognisant of the fact that this book is not exhaustive on all climate compatible development issues, we are convinced that it will narrow some gaps in knowledge on climate compatible development in the region. We hope that it will stir the minds of climate change researchers and practitioners to complete or complement the work that we have started. This book is therefore a MUST-READ for all because it will re-invigorate research uptake in Africa that will achieve the following:

1. Develop policy documents with by-laws and legislation on green economy stating the strategies and indicators of the same to be adopted by all sectors of the economy. This will include mobilisation of investments for CCD toward achieving sustainable development.
2. Integrate climate compatible development into existing multi-stakeholder national development and poverty reduction planning processes (policy makers, global practitioners, NGOs, academics and private sector stakeholders). This will invigorate public-private partnerships in implementation of CCD.
3. Develop reform policies and provision of incentives for funding agencies that go green, for example, sectors and domestic policies supporting the greening of buildings, transportation, tourism and energy sectors in home market.
4. Enact tax reforms including carbon tax, where those that are not compliant to green financing should be highly taxed.
5. Help countries to redirect public investments and green public procurement.
6. Promote making of changes in the understanding and commitment of decision makers around climate compatible development issues.
7. Promote making of changes in institutions and institutional capacity to respond appropriately to climate compatible development needs and demands.
8. Enable countries to develop assessment tools and indicators to climate compatible development and develop databases for green financing economy.
9. Promote an economy that is self-directed, sensitive and resistant to dumping and investment partners that undermine climate compatible growth and development.
10. Enhance productivity in management of ecological resources including laws and legislation on environmental conservation.
11. Encourage governments providing incentives for green enterprises and increasing extension and entrepreneurial education.
12. Strengthen market infrastructure and market-based mechanisms for clean technologies that encompass indigenous knowledge.
13. Increase investments in climate for innovation and commercialisation of green products and clear communication on mainstreaming green economy to the public.
14. Promote investment in research and development in climate change governance and green economy.
15. Increase investment in resilience to climate change and other external shocks.
16. Promote changes in the quality of life for people most affected by climate change, including social protection for the vulnerable groups.

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CHAPTER ONE

Mainstreaming Climate Adaptation into Agricultural Planning and Development in Kenya

Christopher A. Shisanya

Abstract

The agriculture sector is one of the economic sectors in Kenya most vulnerable to climate change largely due to the increasing temperatures, changing rainfall patterns and extreme weather events. Some crops are expected to experience more favourable growing conditions as a result of climate change, whereas others will find future climatic conditions intolerable. The agriculture sector is responding to effects of climate change, and effort has gone into integrating climate change impacts into agricultural programmes and projects. Mainstreaming climate change adaptation in agriculture describes a process of 'climate-proofing', which is essentially concerned with protecting agricultural development investments and outcomes from the impacts of climate change. The objective of this study was to examine the extent to which the government of Kenya has mainstreamed adaptation to climate change in agricultural planning and development. To achieve this, a comprehensive review of relevant literature on the subject was undertaken and subjected to content analysis based on the principles of scientific method, namely: objectivity, systematicity, and generalisability. The Action Adaptation theory guided the study. Findings show that Kenya has made milestones in mainstreaming climate change adaptation in agriculture through its blueprint documents of National Climate Change Response Strategy and the National Climate Change Action Plan. However, to maximise benefits, a comprehensive institutional and mainstreaming framework, with defined roles and responsibilities, is needed to be in place. Such a framework would capture the need to respond to climate change in the context of the devolved government system in Kenya.

Keywords: Agriculture, climate change, climate-proofing, climate-smart agriculture, Kenya

1. Introduction

Throughout the world, national governments are becoming increasingly concerned about the likelihood of a changing climate impeding achievement of their development objectives. Higher temperatures, altered precipitation patterns, more frequent and/or extreme weather events, rising seas are manifestations of climate change, and each has clear implications for food security, water security, infrastructure development and the overall health and well-being of people, ecosystems and economies. To ameliorate

these risks, governments are increasingly initiating efforts that facilitate adaptation to climate change¹.

Adapting to a changing climate is a long-term, continual process that will require the implementation of some targeted, standalone measures. It is widely understood that adapting to climate change will also require the integration or mainstreaming of adaptation needs into development processes. Mainstreaming climate change adaptation involves systematically assessing and incorporating information and measures related to climate risks and vulnerabilities into development policies, plans, institutions, programs, projects and everyday decision-making (OECD 2009; SPC and GTZ 2010). This process of embedding climate change considerations into the everyday culture of decision-making, as opposed to treating adaptation as a parallel, separate process, is perceived to provide a number of benefits (Huq and Burton 2003; Klein *et al.* 2007; Newell 2004; OECD 2005; World Bank 2006). Mainstreaming expands the range of avenues through which risks may be assessed and adaptation measures introduced, a characteristic that is particularly important given the pervasive implications of climate change across a diversity of socio-economic and ecological issues. It also enables a wide array of existing technical, human and financial resources to be leveraged in support of efforts to adapt. Trade-offs and synergies between adaptation needs and other priorities may be more fully identified and assessed when climate risks are examined in conjunction with other risks. Mainstreaming also is perceived to be a more cost-effective process, and one that reduces exposure to unacceptable and unexpected risks. Finally, mainstreaming allows for a continual reassessment of the risk posed by a changing climate in light of new scientific analysis and evolving socio-economic and ecological circumstances.

Mainstreaming climate change adaptation at the national level is viewed as being particularly important. National governments set the vision for a country's medium- and long-term development, and its policies, legislation and regulations form the framework within which sectors and sub-national governments operate. Mainstreaming at the national level therefore is critical in establishing an enabling environment for adaptation. However, while there is a recognition of this critical need, little progress has been made to mainstream adaptation at the national level in comparison to integration into sectoral development strategies. Few examples exist of adaptation having been mainstreamed into critical initiatives such as poverty reduction policy frameworks and national sustainable development strategies (Kramer 2007; Mitchell, Tanner and Wilkinson 2006; OECD 2009; SPC and GTZ 2010).

Given the critical role of national governments in shaping the future direction of developing countries, and the significant risk posed by climate change, particularly for the least developed countries, there is an urgent

need to accelerate the mainstreaming of adaptation into national level policies.

1.1. Statement of the Problem

Adaptation to climate change is a multi-faceted, iterative and long-term process which involves numerous actors collaboratively changing societal practices and behaviours in order to minimise climate-related risks and take advantage of emerging opportunities. A widely accepted means of preparing for climate change is to mainstream adaptation needs into development processes. Mainstreaming climate change adaptation involves systematically assessing and incorporating information and measures related to climate risks and vulnerabilities into development policies, plans, institutions, programs and projects. It means building a culture in which consideration of potential climate risks, and strategies for addressing these risks, is embedded into everyday decision-making. This chapter examines the extent to which Kenya's current efforts by public and private sectors, NGOs and CBOs, including regional and international organisations have achieved in mainstreaming climate change in planning and development in the agricultural sector.

1.2. Methodology

This chapter is based on secondary data from a comprehensive literature review conducted. To understand the progress made thus far and the challenges experienced in tackling climate change in Kenya's agricultural sector, we undertook a review of the existing literature on climate change in Kenya. The literature served the following purposes:

- to identify the key actors working on agriculture and climate change in Kenya expound on their roles for the selection of key actors for interviews;
- to provide information on the current policy initiatives on climate change as well as understand the policy context and the main drivers; and
- to identify the key themes and narratives shaping the discourse on climate change and agriculture in Kenya.

1.3. Organisation of the Chapter

This chapter is structured as follows. Section 1 introduces the chapter, states the problem and highlights the methodology used in the preparation of this chapter. Section 2 details the theoretical and conceptual underpinnings of the study, concept of adaptation and entry points for mainstreaming adaptation. The role of agriculture in Kenya's economy is captured in Section 3. Section 4 examines the efforts so far made in Kenya as far as mainstreaming climate change adaptation into National Development Planning. Section 5 specifically focuses on climate change adaptation in the Kenyan agricultural sector, while Section 6 elucidates the Strategic Action Plan for mainstreaming climate change adaptation in

agricultural development and practices. Section 7 highlights barriers to mainstreaming climate change adaptation in agriculture. Section 8 examines the role of institutions in climate change adaptation in agricultural development and highlights governance-related issues in climate change adaptation are presented in Section 9. Finally, Section 10 concludes the chapter and draws implications.

2. Theoretical and Conceptual Underpinnings

This chapter is informed by the Action theory of adaptation (Eisenack and Stecker 2010; Füssel 2007a; 2007b; Kelly and Adger 2000) (Fig. 1). A stimulus is a change of biophysical (in particular meteorological) variables triggered by climate change. In a very precise meaning, this has to be distinguished from weather events. Stimuli refer to new statistical properties as averages intensity, higher momenta, or frequencies. They can also refer to abrupt large-scale events in the earth system. A stimulus is only relevant for adaptation when it influences an *exposure unit*. The latter term broadly refers to all those actors, social, technical or non-human systems that depend on climatic conditions, and are therefore exposed to stimuli. By an *impact* of climate change we understand a combination of a stimulus and an exposure unit. More broadly, it can be a set of stimuli with an associated set of exposure unit. In our context, we examine the impact of climate change on agriculture (*exposure unit*) and how the government (*operator*) has put in place measures to adapt to this situation.

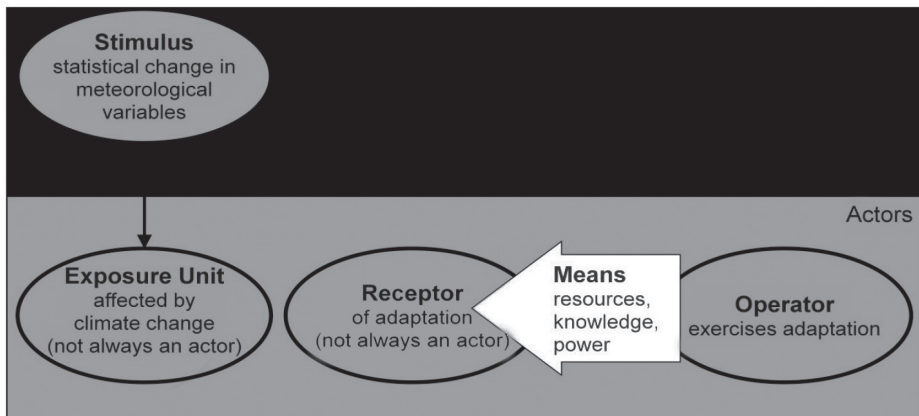


Fig. 1. Schematic Representation of Some Core Concepts of the Action Theory of Adaptation.

SOURCE: Adapted from Eisenack and Stecker (2010)

Note: Exposure unit, receptor and operator can be actors. They are not necessarily identical.

On the other hand, a review of literature on mainstreaming in other areas, such as gender, HIV/AIDS, and environmental change, provides us with

some key lessons that we can translate into mainstreaming climate resilience. We have summarised these here.

i. Mainstreaming Is Not a New Strategy

- a) Despite extensive use of the term ‘mainstreaming’, there is not a clear understanding of the concept.
- b) To simplify matters, we should think of mainstreaming in terms of principles, systems, framework tools and discrete tools and techniques (Mackay and Bilton 2003).
- c) There is no blueprint approach to mainstreaming: tools and approaches need to respond to the specific country context and issue(s) of concern (IIED and UNEP World Conservation Monitoring Centre (WCMC) [n.d.]).

ii. Typology of Mainstreaming Strategies

- a) The three main approaches to mainstreaming are: **integrationist**, based on ‘adding on’ an issue to current development plans and policies without questioning and addressing inherent social inequalities and state interests; **agenda setting**, which is more consultative and allows the recognition of marginalised voices; and **transformative**, which aims to ‘transform the existing development agenda’ (Jahan 1995). The latter is needed to address and overcome existing power differences and interests (Daly 2005) and ultimately lead to an empowerment of diverse actors (Verloo 2005).
- b) Mainstreaming should aim to transform the organisational culture of governments and public bodies and to improve the quality of public policy and of governance itself (Mackay and Bilton 2003).

iii. Entry Point and Enabling Factors

- a) The ‘entry points’ are often key points in mainstream policy and planning cycles, particularly those concerning safeguards, prioritisation and investment choices (IIED and UNEP WCMC [n.d.]).
- b) It is important to differentiate between institutional (upstream) and operational (downstream) mainstreaming approaches, which will influence the choice of entry points.
- c) Mainstreaming is an iterative process which does not necessarily follow a set of sequential steps (IIED and UNEP WCMC [n.d.]). While strategic political will decisions on mainstreaming are taken at the top, implementation design decisions should be taken at the lowest possible level of public authority, closest to the population concerned. There is a need to balance top-down and bottom-up processes; and flexibility and adaptive management are key requirements.

iv. Achievements and Shortcomings

- a) Despite many successes in awareness raising, capacity building and institutional and policy development, mainstreaming efforts often fail to achieve their goals and objectives.
- b) Leadership has not consistently supported the implementation of gender mainstreaming policy, resulting in 'policy evaporation'. Mainstreaming requires change. Organisational culture must break with old ways of thinking and acting, and accept and act on new concepts. (African Development Bank 2012, NORAD 2006).
- c) Additional constraints identified include: lack of data, information, skills and institutional capacity to work on environment-development links; lack of successful models; and lack of political will for change.
- d) For most developing countries, mainstreaming both responds to, and is challenged by, competition with many other policy priorities in the face of limited resources (IIED and UNEP WCMC [n.d.]).

2.1. Adaptation to Climate Change

Adaptation to climate change is a multi-faceted and iterative process. In the near- and long-term, it requires adjustments in societal practices and behaviours; the generation and sharing of knowledge; the development of new or re-purposed tools and technologies; and collaboration between different disciplines, sectors and jurisdictions. National governments are well-placed to play a critical role in shaping these responses by creating an enabling environment that facilitates adaptation by individuals, communities, businesses and sectors. The power of national governments in this context stems from a combination of their roles in policy formation, policy coordination, information and knowledge management, and international relations.

Using the levers at their disposal, national governments can put in place the incentives (and disincentives) needed to ensure that climate risks are integrated into decision-making. Policies set at the national level establish the framework within which lower levels of government and sectors operate (Hay *et al.* 2005; OECD 2009). National governments also typically lead efforts to ensure policy coherence horizontally between government departments and sectors, and vertically between different levels of government (OECD 2009). These efforts can ensure that efforts to reduce climate risks are consistently harmonised with national development plans and processes (Hay *et al.* 2005). Information important to adaptation decision-making, such as climate data, vulnerability assessments and economic analyses, is often collected by national-level institutions and agencies. As well, national governments take the lead in establishing and implementing international and regional agreements, such as those that govern the management of trans-boundary resources whose abundance might be altered by climate change. Relationships with the international donor community, which are of particular importance to many vulnerable developing countries, are also generally mediated at the national level

(OECD 2009). Overall, mainstreaming adaptation at the national level enables responsibility for managing climate risks to be shifted from individual ministries or agencies to all sectors of government as well as the private sector and civil society (Mitchell, Tanner and Wilkinson 2006).

2.2. Entry Points for Mainstreaming Adaptation

Mainstreaming climate change adaptation needs to be a strategic, country-led approach. It needs to integrate climate adaptation into development planning in efficient and effective ways. It must enable development planners to rationalise what **could be done** with what **needs to be done** and what **feasibly can be done** within the structures, resources and capacity available. Of course, this will change and develop over time as the mainstreaming process continues.

For national governments to create an enabling environment for adaptation, adjustments will be needed to existing and future policies, institutional mandates and governance structures. It will require assessing the degree to which existing and future strategies, policies, plans and programs are vulnerable to climate variability and climate change; identifying entry points through which the design of government policies and measures may be altered; and implementing adjustments to these policies and measures as needed to minimise risks and take advantage of emerging opportunities (OECD 2009). As identified by the OECD (2009), a number of entry points exist within the national policy cycle through which these adjustments can be made.

One of these entry points is **policy formation and revision**. Long-term (15 to 20 years) national vision documents and sustainable development strategies, along with shorter-term (three to five years) national policies like poverty reduction strategies, establish the overarching framework within which operational plans and resource allocations are made. These long- and short-term policies are therefore critical entry points for mainstreaming adaptation. By incorporating keywords into these national policies, governments signal to their citizens, bureaucracy and the international community their awareness of the risks posed by climate change to their development goals— and the need to act upon this awareness. Mainstreaming is further facilitated by governments applying a climate lens to the goals and plans articulated within their policies. This process can expedite identification of potential risks and ensure that policy objectives can be met within a changing climate. It can also help ensure that planned investments do not prove to be maladaptive over the near- and long-term (OECD 2009).

National planning processes provide a second entry point. As governments strive to maintain policy coherence, the integration of adaptation into national policies should encourage subsequent mainstreaming into operational action planning and budgeting processes, such as those associated with medium-term or five-year plans. Adaptation

mainstreaming into national planning processes can be facilitated by directly integrating specific adaptation components into national plans (e.g. targeted projects, research and assessments) that address unique needs brought about by climate change. It can also be accomplished by modifying current guidelines and criteria that guide planning processes, such as Strategic Environmental Assessments, to enable the application of a climate lens to existing and emerging plans. It can also be enabled through the creation of standalone adaptation strategies and plans that encourage cross-sectoral cooperation (OECD 2009).

Resource allocation processes provide a further entry point. As budgetary allocations are the main instrument through which national governments operationalise achievement of their policy objectives, particular attention should be given to integrating adaptation into national economic planning and budgetary processes (OECD 2009). Integrating adaptation into these processes can assist national governments to minimise their financial risk, promote macroeconomic stability, set aside sufficient funds to manage the consequences of climate shocks, and provide support for adaptation activities at the local and sectoral levels (AfDB *et al.* 2003). It can also help ensure that climate risk management measures are properly funded and balanced against competing priorities (Mitchell, Tanner and Wilkinson 2006). Taking into consideration existing analysis and policy objectives, governments can choose to prioritise the allocation of funding to vulnerable sectors and regions, and to projects and programs expected to reduce vulnerability to climate change. Budgetary resources can also be allocated to a national fund established specifically to enable ministries to cover the additional costs imposed by adaptation (OECD 2009).

By mainstreaming adaptation into policy formation, planning and resource allocation processes, national governments strengthen their commitment to managing climate risks and can promote mainstreaming adaptation at the sub-national and sectoral levels. Beyond these domestic policy entry points, national governments can promote adaptation mainstreaming through the relationships they build with other countries and the commitments they make as part of international processes. For instance, climate change adaptation needs can be integrated into regional agreements surrounding the management of trans-boundary water resources. As well, actions taken by national governments as part of fulfilling their responsibilities related to the implementation of various multilateral agreements including the United Nations Framework Convention on Climate Change (UNFCCC), United Nations Convention to Combat Desertification, the United Nations Convention on Biological Diversity, and the Ramsar Convention can be accomplished in a manner that promotes resilience to climate change (OECD 2009).

Role of Agriculture in Kenya's Economy

Agriculture is the most important sector in sub Saharan Africa (SSA) and it is set to be hit hardest by climate change. Climate change, with its effects on temperature and precipitation, threatens this important economic activity. Small-scale farmers that dominate the sector and derive their livelihoods from agriculture are reliant on rainfall. These farmers face the challenges of land degradation, poor soil fertility management, and continuous cropping. Sluggish growth in agricultural productivity translates into slow overall growth and general low per capita income levels.

Agriculture is a central sector of the Kenya's economy. The sector contributes about 25 per cent of the Gross Domestic Product (GDP) and another 25 per cent indirectly (GoK 2010a). The sector contributes about 65 per cent of Kenya's total exports. It is therefore a major foreign exchange earner for the country. The sector also provides employment to a large section of the Kenya's population. According the Agricultural Sector Development Strategy (ASDS) (Mabiso, Pauw, and Benin 2012), the agriculture sector provides more than 18 per cent of formal employment and more than 70 per cent of informal employment in the rural areas (GoK 2010a).

The sector comprises six subsectors: 1) industrial crops, 2) food crops, 3) horticulture, 4) livestock, 5) fisheries, and 6) forestry. According to GoK (2010a), the industrial crops contribute 17 per cent of the AgGDP and 55 per cent of agricultural exports. Horticulture is currently the largest subsector, contributing 33 per cent of the AgGDP and 38 per cent of export earnings. Food crops contribute 32 per cent of the AgGDP but only 0.5 per cent of exports, while the livestock subsector contributes 17 per cent of the AgGDP and 7 per cent of exports. In general, the full potential of the agricultural sector remains underutilised. In particular, the livestock and fisheries subsectors have huge potential for growth that has not been exploited. The agriculture sector is the primer for industrialisation; it supplies the raw materials for industries, for instance timber for the paper manufacturing industry, skin and hides for the leather industries, and raw food stuff for the food processing industry. Furthermore, the sector is also a market for the industrial goods, such as machinery, equipment, fertiliser and other agro-chemicals that are used in the farming process. It has strong backward and forward linkages to the rest of the economy. It promotes and creates many off-farm service activities such as transportation and supply chains for agricultural inputs. It provides many employment opportunities along the various value chains— from production, processing, wholesaling, and retailing to final consumption. In addition, the sector generates foreign currency through export process of agricultural products. It creates a source of employment to the population through farming, business, industrial processing and research activities. The purchasing power of the population is improved through income generation, hence creating a market for industrial products.

3.1. Agriculture and Economic Growth

Agricultural sector is the major driver of the overall economic growth in Kenya (GoK 2010a). Available statistics clearly show that growth of the national economy is highly correlated to growth and development in agriculture (Figure 2). During the first two decades after independence, the sector and in turn the whole economy recorded high and impressive levels of growth. On average, the agriculture sector grew at an average of 6 per cent per annum while the overall economic growth averaged 7 per cent (GoK 2010a).

From the late 1970's to late 1990's, the agriculture sector experienced a declining growth. Correspondingly, the overall economic growth also took a downward turn. A clear reversal of the declining trend has been evident since the early 2000's; the agriculture sector and the overall economy have recorded positive growth. Based on the evidence from the last five decades, it is very clear that Kenya's overall economic growth is intertwined with the growth of the agricultural sector; indeed it is not a *cliché* to say that agriculture is the engine of economic growth in Kenya.

Given such critical role of the sector in generating economic benefits, accelerated growth in agriculture should have the potential to stimulate wider economic growth and reduce poverty significantly. As noted in the agricultural sector development strategy (ASDS 2010–2020), sustained agricultural growth is critical to uplifting the living standards of our people as well as generating rapid economic growth. The ASDS set the following targets to be achieved by 2015 (GoK 2010a; GoK 2007):

- reduced number of people living below absolute poverty lines to less than 25 per cent, to achieve the first MDG (Millennium Development Goal);
- reduced food insecurity by 30 per cent to surpass the MDGs; and
- increased contribution of agriculture to the GDP by more than KES 80 billion per year as set out in Vision 2030.

The critical role of the agricultural sector in national development and poverty reduction efforts is very clearly demonstrated in the ASDS and other government policy documents.

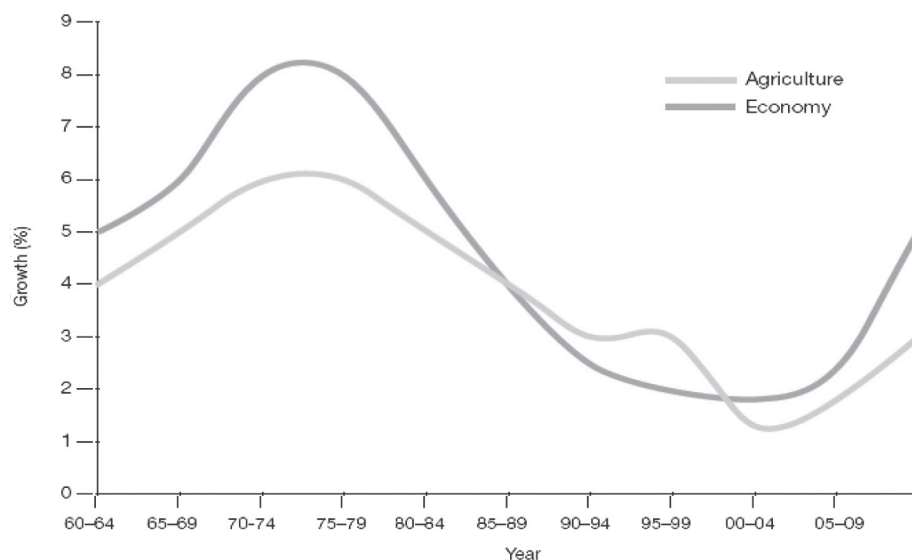


Figure 2. Trends in Agricultural and Economic Growth (1960–2008)

SOURCE: Adopted from the Agricultural Sector Development Strategy (ASDS) (GoK 2010a)

3.2. Agriculture and Food Security

The achievement of national food security is to be a key objective of the agricultural sector. Agriculture ensures a constant food supply and food security for the population, which is essential for a healthy and energetic population to drive the economy. It also saves the country funds that would have rather been used in the importing of food from other countries. This in turn has a positive effect on the country's balance of payments and there is surplus money to invest in other areas of the economy, such as social overheads, roads, and hospitals. In general, the agricultural sector in Kenya, supplies food for the population but for several commodities, such as maize, rice and sugar, local production is not sufficient to meet the local food demand. The deficits are closed through importation. According to the Kenya Food Security Steering Group, the country has been facing higher frequencies of severe food shortages in the recent times especially due to higher frequency of extreme weather that are related to climate change and climate variability. Official estimates indicate over 10 million people are food-insecure with majority of them living on food relief. Households are also incurring huge food bills due to the high food prices. Maize, being the staple food due to the food preferences, is often in short supply and most households have limited choices of other food stuffs.

3.3. Agriculture and Poverty

Approximately 80 per cent of the Kenya's population lives in rural areas and relies on agriculture for its livelihood (UNDP 2013). According to the World Bank Development Indicators for 2010, poverty is still high in Kenya (World Bank 2010), where the poverty headcount ratio is estimated at 45.9 per cent (*ibid.*). The rural economy is dominated by the smallholder subsistence farmers who produce about 75 per cent of the total agricultural output. The areas with high potential for agriculture are located in the central highlands and highlands to the west of the Rift Valley where population density and population-to-land ratios are very high. The poorest communities in the country are located in the sparsely populated arid zones mainly to the north of the country. Among the rural poor in Kenya are the following categories: smallholder producers, pastoralists, farm labourers, unskilled and semiskilled workers, women-headed households, people with disabilities and orphans.

Available evidence shows that agriculture-led growth in Kenya is more than twice as effective in reducing poverty as industry-led growth (Mabiso, Pauw and Benin 2012). The analysis undertaken by these authors indicates that if Kenya were to achieve the Comprehensive Africa Agricultural Development Programme target of 6 per cent for the agriculture sector, levels of poverty would fall to 24 per cent by 2020. To achieve this level of growth, substantial investments would have to be committed to subsectors, such as cereals, roots, pulses, fruits and tea. These sub-sectors would have to grow at over 6 per cent per annum. In the semi-arid areas of the country, investment in irrigation and infrastructure offer the best potential to reduce poverty significantly. In general, the transformative process of the agricultural sector would have bigger multiplier effects in other sectors of the economy which would absorb more and more labour. The population that would remain in the agriculture sector would have higher productivity and high levels of income (FAO 2008). The key to better performance in agriculture lies in boosting smallholder productivity and developing non-farm activities (FAO 2012).

3.4. Impact of Climate Change on Agriculture in Kenya

The agriculture sector, including crops and livestock, is a priority in *Vision 2030* because it plays a critical role in improving livelihoods, enhancing food security and increasing GDP and employment (GoK 2007). *Vision 2030* aims to achieve an innovative, commercially-oriented, modern agricultural sector through institutional reforms, increased productivity, land-use transformation, increased access to markets and development of arid and semiarid lands (ASALs). The *Agricultural Sector Development Strategy 2010–2020* sets out a detailed plan to “position the agricultural sector as a key driver for delivering the 10 per cent annual economic growth rate envisaged under the economic pillar of *Vision 2030*.” The vision of the document is “a food secure and prosperous nation” and the strategy aims to increase productivity, commercialisation and

competitiveness of agricultural commodities and enterprises; and develop and manage key factors of production. Also important is government's goal of 10 per cent farm forest cover on all agricultural landholding (GoK 2010b).

3.4.1. Risks and Impacts

The agriculture sector is very sensitive to climate change, meaning that agricultural systems will need to adapt to ensure provision of adequate food for the growing population and improve production of export crops, which are an important source of foreign exchange earnings. The livestock sector is also very climate-sensitive and is already experiencing negative impacts from current climate (for example, drought leading to livestock morbidity and mortality. At the same time, the sector is a large emitter of greenhouse gases, responsible for about 30 per cent of Kenya's emissions in 2010 (UNDP 2013). Agriculture offers great potential for synergies between the objectives of food security, poverty reduction, adaptation and mitigation. The sector is one of the economic sectors in Kenya most vulnerable to climate change largely due to the increasing temperatures, changing rainfall patterns and extreme weather events (UNDP 2013). Some crops are expected to experience more favourable growing conditions as a result of climate change, whereas others will find future climatic conditions intolerable. Equally, some regions (namely the mixed rain-fed temperate and tropical highlands) are projected to experience an increase in crop yields, whereas others (mainly the ASALs) are projected to witness a significant decline in crop yields and livestock numbers as water resources become increasingly scarce. These patterns are largely driven by regional variability in future precipitation and geographic exposure to extreme events, particularly drought frequency. The Adaptation Technical Analysis Report, developed as part of Kenya's National Climate Change Action Plan (NCCAP), identified the following specific climate risks in the agriculture sector (GoK 2013; GoK 2010c):

- **Less days for crop growth:** Both incremental (gradual) climate change and more frequent extreme events, such as flooding and prolonged drought will cause a decrease in reliable cropping days, making crop failure more likely.
- **Less water availability for crop growth:** An increase in average annual temperature and increase in evapo-transpiration will decrease water availability and cause a decrease in agricultural productivity, particularly in the ASALs that are already experiencing prolonged drought.
- **More droughts:** The increased frequency of droughts causes water shortages for domestic use, crops and livestock.
- **Unpredictable climate patterns disrupt agricultural planning:** Unpredictable precipitation during both the short and long rains, together with extreme events, particularly increased frequency of droughts, causes a decline in agricultural productivity. Declines in

livestock-based productivity are particularly a problem in the ASALs. Changes in the timing of long and short rains make it difficult to plan sowing and harvest times, causing lower yields and greater food insecurity.

- **Increased flooding of agricultural land:** Extreme rainfall events can cause flooding of agricultural land and destruction of crops.
- **More pests:** Incremental climate change causes biodiversity loss and emergence of new pests.
- **Temperature changes affect crop and livestock potential:** Increase in average annual temperature causes shifts in tolerable limits for some crops (such as tea and coffee), and causes decline in fish stocks in lakes and rivers. In addition, low temperature causing frost in the tea estates has resulted in low tea productivity.

3.4.2. Recommended Actions

The agriculture sector is already responding to the effects of climate change, and effort has gone into integrating climate change impacts into agricultural programmes and projects. An integrated approach to climate change that can advance both climate resilience and low carbon objectives is particularly applicable in the agricultural sector. Many agricultural management practices that reduce climate vulnerability— and improve agricultural production potential — also reduce emissions. Importantly, Kenya will not adopt measures to reduce greenhouse gas emissions if they threaten the country's ability to feed its population or reduce export earnings (GoK 2013; GoK 2010c). The NCCAP adaptation analysis indicates that adaptation efforts should focus on implementing measures that help build rural livelihoods that are more resilient to climate variability and disaster. Important adaptation actions include the promotion of drought tolerant crops, water harvesting, integrated soil fertility management, insurance schemes, price stabilisation schemes for livestock, strategic food reserves, and mainstreaming climate change into agricultural extension services (GoK 2013; GoK 2010c).

In regard to livestock, priority low carbon climate resilient actions include improved management of grazing systems, livestock diversification, breeding of animals to improve their ability to adapt to climate change and produce lower methane emissions, and provision of accessible climate information to farmers and pastoralists (GoK 2013; GoK 2010c). Adaptation actions to improve the resilience of livestock are particularly important for the ASALs. Other important actions can build knowledge and awareness of mitigation opportunities, such as dairy herd management (improved feed and breeding of high yielding cattle), manure management through biogas promotion, and rangeland pasture rehabilitation, management and conservation. Priority areas for low carbon development identified in the NCCAP are identified below. It is important to note that these actions also bring strong climate resilience benefits (GoK 2013; GoK 2010c).

- Agroforestry involves combining trees and shrubs with crops and/or livestock. This combination of agriculture and forestry techniques builds more robust, productive, resilient and diverse agro-ecological systems and has the potential to abate 4.2 million tonnes of carbon dioxide equivalent (MtCO₂e) by 2030.
- Conservation tillage has food security, livelihoods, climate resilience and low-carbon benefits. These tillage techniques disturb the soil as little as possible and leave crop residues on the surface, which reduces water movement and soil erosion. It has the potential to abate 1.1 MtCO₂e by 2030.
- Reducing the use of fire in cropland and rangeland management has the potential to abate 1.2 MtCO₂e by 2030.

4. Prior Efforts in Mainstreaming Climate Change Adaptation into National Development Planning

There are some examples of mainstreaming climate change into national development planning that give confidence for similar successes in the agriculture sector. March 2013 saw the implementation of the new Kenyan constitution and this was celebrated by peaceful democratic elections at national and county levels. Kenya has the political will to mainstream climate change adaptation in its planning processes as reflected in the NCCAP, which also indicates the level of Kenya's commitment to low-carbon development. The country has a climate change committee at the national level, chaired by the Deputy President. The Committee does the overall coordination of mainstreaming climate adaptation in the country. The committees' round table is undertaken every quarter with stakeholders to discuss climate change adaptation. These include the line ministries and agencies, non-state actors, such as the Kenya Association of Manufacturers, the Kenya Private Sector Alliance, individual industries and national NGOs, such as the Kenya Climate Change Working Group (KCCWG), the Kenya Forest Working Group, Pact-Kenya, and Forest Action Network. There are also international NGOs, including the Africa Wildlife Foundation, WWF, the International Union for Conservation of Nature, Oxfam and Care, among others, which undertake environmental conservation and climate change-related activities. Prior to 2013, the Prime Minister in the previous government administration was allocated one hour in parliament every week to answer queries regarding climate change adaptation.

The Ministry of Environment Water and Natural Resources (MEWNR) is the lead agency and has a climate change secretariat tasked with coordinating the implementation of the action plan to operationalise the National Climate Change Response Strategy (NCCRS) and other climate change activities. Other agencies within this Ministry include the National Environmental Management Authority (NEMA) — the designated national

authority with responsibility for approving Clean Development Mechanism projects, and the Kenya Meteorological Services, whose mandate is research, prediction and dissemination of climate change information, as well as issuing early warning of extreme weather events. Also the Department of Resource Survey and Remote Sensing, charged with continuous monitoring of natural resources in Kenya, is within the ministry. It should be noted that coordination and governance are spread across different government ministries and agencies. Other government line ministries and agencies involved are: the Office of the President, the MEWNR, the Carbon Finance Unit (CFU) under the National Treasury (Department of Finance), the Ministry of Devolution and Planning and Vision 2030, Ministry of Agriculture, Livestock and Fisheries, Ministry of Health, Ministry of Transport and Infrastructure, and Ministry of Interior and Coordination of National Government. All of this shows the level of commitment technocrats have in pushing up the climate change adaptation agenda. Political will is demonstrable by both politicians and technocrats in the government, the parliament and beyond.

The impact of political will on mainstreaming is that the country has managed to prepare the 2010 NCCRS and the 2012 NCCAP. This has been done under the political leadership of the Minister for Environment and Mineral Resources and the technical support of the Ministry of Environment. There are efforts to embed climate change in 'Vision 2030' – the country's development plan for the next 17 years. This will ensure that climate change adaptation is mainstreamed in the medium-term plans, sectoral plans, ministries' strategic plans and county development plans. Climate change mitigation and adaptation are emphasised in the country's medium term plan for the period 2013–2017. Kenya is looking at a low-carbon development pathway. Climate change adaptation has been mainstreamed into the county profiles (precursors of development plans) that were prepared under the leadership of District Development officers (economists), charged with the responsibility of coordinating development activities at the district level.

The 2010 constitution established 47 counties in the country (GoK 2010b). At the time of writing, climate change adaptation had been mainstreamed in all of them. Further demonstration of Kenyan political will is the decision by the Ministry of Planning to introduce use of the 'Threshold 21' (T21) model (UNDP 2013; GoK 2013a). This is based on system dynamics and is designed to support national development planning. The model integrates in a single framework the economic, social and environmental aspects of development. Customisation of the Kenya T21 is unique as it fully incorporates the impacts of climate change across sectors and selected mitigation and adaptation measures. Economists conduct a series of policy-neutral and policy-intervention forecasts with T21, to show the current and future trajectory of national development in Kenya and assess the implications of climate change under different scenarios and adaptation

measures on national development, within the context of Vision 2030 (UNDP 2013).

The T21 model shows how annual temperature and rainfall patterns will impact on the agricultural, energy, water and forestry sectors, among others. The model shows that temperatures will increase steadily from 23°C (2010) to 28.02°C (2050). This represents an increase in temperature by 5.02°C and implies a further increase. The model shows that rainfall patterns have been irregular and will be unpredictable. For example, in 1980 average rainfall was 800mm. It declined to 600mm in 1984, increased to 1,000 (1990), 1,300 (1997), reduced drastically to 600 (2000), and increased to 1,200 in 2008. This evidence helps policy-makers plan for the future as it is now evident that the trend will continue in the future without a reduction in greenhouse-gas emissions (UNDP 2013).

5. Climate Change Adaptation in the Kenyan Agricultural Sector

With three quarters of Kenya's population dependent on agriculture for their livelihoods, it is a country in need of climate-smart agriculture. In addition to increasing average temperatures, Kenyan farmers face more prevalent droughts and floods, crop failures, rising rates of climate-related disease, such as malaria, and the conversion of medium and high potential land to arid and semi-arid land. Economic impacts of climate change in Kenya across sectors are estimated to range from US\$1 to US\$3 billion per year (GoK 2010a).

With a fully developed NCCRS, Kenya may become the first country in Africa to establish an independent climate change authority that will guide the implementation of a strategy of this kind (Chonghaile 2012). Agriculture will be a major focus on Kenya's NCCRS, with substantial needs for adaptation and mitigation identified. Kenya's early experiences, as it has worked to bridge sectoral divides within the context of climate change and agriculture, are instructive not only for Kenya's future development, but for other countries in Africa and throughout the world that face similar challenges. These lessons might also inform the efforts of Kenya in its shift towards landscape scale planning. Kenya is in the process of developing a national catchment management policy, in which agricultural landscapes would be managed to achieve not only agriculture and watershed management objectives, but also other related goals, such as food security, climate adaptation and biodiversity conservation. In this section, we first present the current national strategies and policies that are developing in Kenya to support climate-smart agriculture and review the institutional response within government to these strategies. These experiences are then analysed to identify critical lessons and recommendations for future action.

5.1. The Development of Policies and Institutions for Climate-smart Agriculture in Kenya

5.1.1. National Climate Change Response Strategy

Kenya's NCCRS was developed as a framework for integrating climate concerns into development priorities, government planning and budgeting. The NCCRS development process, led by the then Ministry of Environment and Mineral Resources (MEMR), ran from May 2009 to April 2010. It was developed through a participatory process conducted countrywide through a total of 13 workshops held throughout the country. The full range of stakeholders participated in these workshops including parliamentarians, government workers, private sector actors, environmental groups, youth groups, women's groups, faith-based organisations, development partners and the media. The NCCRS includes indicative budgets and plans for line ministries. The implementation of the full strategy is estimated to cost US\$3 billion annually over the next 20 years, and roughly US\$100 million per year would be needed for adaptation and mitigation activities in agriculture (GoK 2010c). This would require nearly 20 per cent of Kenyan government expenditures planned for agriculture and rural lands for the 2012–2013 fiscal year (GoK 2013a).

Kenya's Agricultural Sector Development Strategy (GoK 2010a) has included climate adaptation as a priority (GoK 2010a), but the agricultural components of the NCCRS provide more details on prioritised activities. On adaptation, it calls for accelerated investment in weather information systems, research on drought tolerant crop varieties, soil and water conservation, water harvesting, and strengthening integrated pest management systems, among others. Kenya has already established itself as a leader in agricultural mitigation by hosting a variety of innovative land-based carbon projects, including Vi Agroforestry's Agricultural Carbon Project which turns sustainable agricultural practices into carbon credits, as well as biogas development programs. Kenya plans to build on this experience and others in mitigation by prioritising activities such as proper management of agricultural waste, organic farming, mulching, agroforestry, and selected application of biotechnology. Although many adaptation and mitigation activities overlap, action plans for implementation will be developed separately through the National Adaptation Strategy and the Nationally Appropriate Mitigation Action (NAMA), respectively. In addition to the NCCRS, Kenya's national policy to support water catchment management approaches, now under development, could help to facilitate the kind of multi-objective landscape-scale planning that could deliver climate-smart agriculture.

5.1.2. Climate Change Bill²

The NCCRS recommends that climate change legislation be enacted to support the mainstreaming of climate change within the national policy. The Ministry of Environment, Water and Natural Resources has supported

the development of a Kenyan climate change bill in collaboration with the KCCWG, a coalition of over 200 civil society groups advocating for action on climate change in Kenya. If passed into law, the bill would establish a National Climate Change Authority as the entity that would coordinate activities across sectors and guide the implementation of the NCCRS.

5.1.3. Government Entities Coordinating Climate Change Activities

The NCCRS recognises that current government institutions are inadequate to handle the complex challenges of climate change. To begin to fill these needs, a Climate Change Secretariat has been established within the MEWNR to coordinate climate change activities across sectors. In addition to the Secretariat within the MEWNR, Climate Change Units have been established within the relevant government ministries, including the Ministry of Agriculture (MoA). The mandate of the MoA Climate Change Unit – staffed by four full-time officers and supported by desk officers from MoA’s other five departments – is to act as a knowledge broker to support the mainstreaming of climate change into all of the Ministry’s projects and programs. It is involved in the development and implementation of policy on climate change in the MoA, the development of programs and projects, coordination and partnership building with relevant stakeholders, and the mobilisation of resources for these activities. It has put in place a Consultative Forum on Climate Change and Agriculture that is an interdisciplinary group of experts to advise the Climate Change Unit.

Another recently created government institution leading on climate change in the Office of the Deputy President is the Climate Change Coordination Unit (CCCU). The CCCU is small; but it is able to provide high level political support to climate change activities in Kenya. Its existence is seen as evidence that the government is prioritising climate change action. The CCCU has a small climate change fund which supports relevant activities within government agencies, such as the NEMA and the Kenya Wildlife Service, as well as the civil society-led KCCWG. Although the CCCU has ambitions of scaling up activities, particularly through their flagship Greening Kenya Initiative — a broad-based green growth plan— it has not yet played a substantial role in supporting climate-smart agriculture activities.

5.1.4. Financing Coordination for Climate-Smart Agriculture

International donors are fairly well-organised within the context of the NCCRS. A donor working group chaired by MEMR and comprised of the UK Department for International Development, the United States Agency for International Development, the Common Market for Eastern and Southern Africa, Climate and Development Knowledge Network and others, meet quarterly to consider how critical needs can be met. These donors have supported the development of NCCRS Action Plans which divide the strategy into eight sub-components. Another relevant donor-funded initiative is the climate-smart readiness mechanism funded by the World Bank. It would support Kenya to scale up some of its early success with climate-smart agriculture by supporting the institutional capacity of the CCU, a climate-smart agriculture investment facility, and the development of a monitoring, reporting and verification (MRV) framework for the national level. The Food and Agriculture Organisation of the United Nations (FAO) is also supporting the development of a climate-smart readiness plan.

5.2. Lessons from Kenya's Experience Planning for Climate-smart Agriculture

Kenya's experience as a pioneer in climate-smart agriculture policy development provides insights into the inherent challenges of building supportive institutions at the national level. These include lessons on integrated planning, financing, and institutional coordination stability. These challenges are expounded here.

Separate planning processes for climate adaptation, mitigation, and sustainable agriculture can complicate policy and program implementation for climate-smart agriculture. The development of the NCCRS was driven by the United Nations Framework Convention on Climate Change (UNFCCC) process and follows its logic that strategies for adaptation and mitigation be developed on different tracks, even in the case of agriculture where many activities provide benefits for both. The NCCRS Action Plan calls for the development of a National Adaptation Program and an agenda for NAMAs, which are being created and financed through different processes. The separation of these processes can be important for planning purposes, and is often necessary to access different streams of funding. However, these different tracks can also lead to inefficiencies within the MoA's climate efforts as the CCU works to coordinate a wide array of climate- and agriculture-related programs. These programs frequently promote similar activities, including those traditionally known as sustainable land management practices that provide adaptation and mitigation benefits.

Funds are uncertain and insufficient: Despite the estimated need of US\$100 million per year to support climate change activities in Kenya's agricultural sector, the funds currently dedicated to climate change

activities within the agriculture budget are limited. Most of MoA's activities that do support adaptation and mitigation are currently categorised as sustainable land management activities, as they have been in the past. While substantial climate change-specific funds have not begun to flow to Kenya— this is not only the case with agriculture— there have been a smattering of adaptation projects that have been funded directly with UNFCCC linked funds, such as the Adaptation to Climate Change in Arid Lands project supported through the Special Climate Change Fund . However, these types of investments from international donors have been limited by the overall levels of international support. Pledges for the Green Climate Fund (GCF) and the associated 'fast start' financing, have been made for US\$30 billion by 2012 (US\$100 billion a year by 2020). From the promised fast-start funds, only 8 per cent has been disbursed, in many cases drawing from development aid funds (Mabiso *et al.* 2012).

Institutional coordination and stability are necessary for long-term planning and investment: As the Kenyan government works to respond quickly to the devastating impacts of climate change, it faces a parallel challenge of building climate change institutions within a context of rapidly developing and complicated international policy and funding processes as well as a dynamic domestic political environment, in which a new constitution is substantially altering the structure of many core government institutions. For example, theoretically, when fully implemented, the new constitution will remove the position of Prime Minister and consolidate and reorganise the ministries, including the MEMR. As government actors cope with this instability, there seems to be some confusion and tension regarding the responsibilities of the various institutions responsible for climate change, particularly the Office of the Prime Minister and the Climate Change Secretariat at MEMR. The creation of a Climate Change Authority, as proposed by the climate change bill would also impact institutional dynamics. Confusion and perceived lack of consultation has the potential to lead to mistrust and sub-optimal coordination among agencies and stakeholders.

Although Kenya is still in the midst of the climate-smart agriculture policy development process and are operating within a highly dynamic political environment, there are still some important steps that could be taken by both the Kenyan government and international donors which would likely support Kenya's efforts to implement climate-smart agriculture. These steps include:

- Ensuring that the Ministry of Agriculture is strongly linked with other climate change stakeholders throughout government, civil society and the private sector;
- Streamlining finance mechanisms to support climate-smart agriculture;
- Improving measurement systems that allow for multi-objective programs; and

- Incorporating climate change strategy and national water catchment policy.

6. Strategic Action Plan for Mainstreaming Climate Change Adaptation in Agricultural Development Planning and Practices

The NCCAP addresses the organisational environment in which policies and programs are developed and implemented. Such a Plan for the Agriculture sector can be envisioned as consisting of four inter-related stages as discussed below.

- 1. Improving the knowledge base and strengthening overall policy/institutional framework for climate change adaptation planning and implementation in the agriculture sector, including resource mobilisation and information management:*** mainstreaming climate change adaptation successfully into the programs of the agricultural sector to ensure that they are “climate proof” requires that clear policies on adaptation are developed in broad consultation with staff and stakeholders down to the farm level. It calls for a process of integrating climate change adaptation from the analysis phase through program design and implementation to monitoring and evaluation. The phases build on one another while information and knowledge management runs throughout all of the stages. Such a Plan to integrate climate change concerns into programming must be accompanied by a strategy to ensure that the working environment is sensitive to climate change issues (e.g. consideration of climate related issues in budgets), and that sufficient technical capacity, institutional arrangements and human resources to successfully mainstream climate change adaptation must be made available. It includes a broad-based plan and strategy for securing internal and external resources needed to fully implement the entire suite of identified strategic actions.
- 2. Instituting Climate-induced Risk Reduction and Risk Transfer Mechanisms:*** The climate-related risks faced by agricultural businesses include flooding (direct damage to assets and indirect damage via supply chain disruption), storms, heat waves, droughts, threats to water availability, pest invasion, crop failures, harmful algal blooms and fish kills, and decimation of livestock. There is a need to manage these risks deriving mainly from climate change and extreme weather events. There is a high potential for growth in Risk Management in Kenya. The Strategic Plan includes introduction of risk transfer and risk management options into the agricultural sector and rapid (and widespread) deployment of same through communication technologies, including mobile phones. There are some (though few) very good examples of the use of micro-insurance for helping climate change vulnerable communities in different parts of Africa. In the Horn of Africa (Ethiopia) HARITA is helping farmers get access to loans that are used to purchase farm inputs with the support of a national organisation who provides

agricultural extension services, including securing better market access for farmers. Another program, Micro-Ensure, introduced one of Africa's first Weather Index Crop Insurance during the 2005–2006 growing season as a pilot in Malawi.

3. ***Capacity Building within the Agriculture Sector for Adaptive Climate Change Response:*** Ministry of Agriculture Livestock and Fisheries (MALF) staff and partners as well as stakeholders in the agriculture sector need to understand the importance and relevance of climate change and community-based adaptation in their work. These skills and knowledge need to be built and are crucial to increasing understanding and effective implementation of adaptation measures. Capacity can be developed through: briefings; training materials; short courses for staff and partners; and regular knowledge and information exchange between staff and partners working in different sectors of the economy and in 'lessons learnt'. It is important to note that "full integration" of staff in this process will take time. It is also essential to periodically assess which stage they have reached and identify priority issues to be addressed with definable, realistic, and measurable goals.
4. ***Monitoring and Evaluation:*** Establishing processes for measuring MALF's effectiveness in mainstreaming and supporting community-based adaptation is critical. How this change can be achieved and how the change can be managed will require continued monitoring and dialogue within MALF to assess progress and approaches. This operational level process can provide opportunities to test and refine mainstreaming tools, to better understand climate change adaptation issues that are relevant for strategic planning and prioritisation, and to build staff and partner capacity to integrate climate change adaptation into their work. The process of mainstreaming should be viewed as open-ended; while organisations should aim to achieve the objectives and targets of the NCCRS, they should also aim to make continuous improvements to their approach. Lessons learnt can be integrated into the design of new programs and implementation strategies. The long-term outcome of mainstreaming climate change adaptation will be the achievement of greater and more equitable sustainable human development not just for stakeholders in the Agriculture sector but, indeed, for all citizens.

7. Barriers to Integrating Climate Change Adaptation into Agricultural Planning and Development

The Kenyan government should continuously review all national agricultural and related policies and programs to determine revisions required in view of expected climate change. Specifically, such a review should address the following challenges/barriers which continue to militate against the effective and efficient adoption of adaptation measures.

- A dearth of efficient and effective agricultural extension services;
- Poor or inadequate delivery systems to ensure timely availability of agro-inputs, overcome the problems of inputs adulterations, high cost of inputs, poor storage, etc.;
- Low level of education in agricultural communities;
- Low level of involvement of educated youth in the agricultural sector;
- Poor agro-meteorological and hydro-meteorological and tide-gauge coverage of the country, and consequent poor weather and river/sea level forecasting capabilities;
- Low levels of new and innovative adaptation measures to climate change in the agriculture sector;
- Lack of procedures and screening tools for integrating climate considerations into project evaluation;
- Continued prevalence of gender-differentiated needs and roles of the society that have put women at a disadvantage in terms of access to land, credit, and farm inputs;
- Low level of climate-smart agricultural development initiatives at the national, state and local government levels;
- Lack of access to loans by real farmers or when available, the operation of unconscionable interest rates and unrealistic repayment schemes that do not take cognisance of farming cycles;
- Poor insurance culture in the agriculture sector due, in part, to certain religious belief systems but also to the lack of liberalisation of the Agricultural Insurance sector;
- Continued embrace of higher carbon policies/practices locked into the country's economic fabric and which are costly and impractical to reverse;
- Poor levels of mechanisation in farming systems—crops, livestock and fisheries;
- Weak culture and systems for organising farmers into effective farmers co-operatives to fight for farmers' rights;
- Poor value chain culture that stresses produce preservation and storage, including agricultural processing;
- Lack of Commodity Markets and price stabilisation mechanisms;
- Low investment in supporting research including application of genetic modification schemes in the search for new adaptive varieties or species in crop farming, livestock rearing and fish farming; and

- Failure to recognise the supportive role of the natural environment in furnishing goods and services critical to successful agriculture.

It is proposed that attempts to obviate these challenges or barriers be based on principles of adaptive management and participatory engagement as the central tenets of the overall implementation strategy of the NCCAP (2013–2017).

8. The Role of Institutions Supporting Climate Change Adaptation in Agricultural Development

By considering institutions as organisations, reference is made to organisational arrangements at scales (global, national and local) with specific roles assigned towards certain outcomes. These organisations often involve both state and non-state actors, including government institutions, civil society organisations, regional organisations, research community, development partners and the private sector. It is the repetitive and structured interactions among these organisations at different administrative scales that are captured as essential for institutions, and more importantly for climate change adaptation. Understanding the specific roles and responsibilities that each organisational institution plays in shaping the adaptive capacity of Nigerian agriculture is central for planning adaptation responses for the benefits of the economy and society at large. Here is a critical look at some of these institutions and their functions.

8.1 Government Institutions

Government institutions in Nigeria include a broad range of actors providing functions within the domain of the state entity. They include line ministries across different sectors (Agriculture, Water Resources, Environment, Economic Planning, etc), parastatal agencies supporting the line ministries (e.g., NESREA, NEMA), and relevant ministries or commissions at the state level, amongst others. A few of their specific roles as government institutions for climate change adaptation are highlighted in Box 1.

Box 1. Role of Government Institutions in Mainstreaming Climate Change Adaptation

- **Policy-making:** This is the central function of this institution – making appropriate policies at the national level— policies that are relevant for climate change adaptation. Such policies would need to provide operational framework for governing diverse adaptation responses and practices at national level. For instance, a policy on flood or drought management in Kenya might be required for managing responses and preparedness to flood disaster. The policy making function of the government institutions provides a framework for mainstreaming climate change adaptation into Nigeria’s economic blueprints and development plans.
- **Providing Overall Leadership and Enabling Environment:** The development of dynamic agricultural systems capable of adapting to climate-related extreme events, often requires a conducive and stable policy environment. Unfortunately, this has been lacking in Kenya. Policy making aside, the government is often required to provide leadership on climate change policy either towards sensitisation programs or even providing enabling environment for other important actors to contribute to sustained efforts towards agricultural adaptation. One example of leadership effort would be the government’s constant communication on the impacts of climate change on the country’s long-term economic and social goals, and vision. One enabling environment is government’s role in initiating conversations on adaptation with other stakeholders by organising multiple stakeholders’ workshops and fora in order to crowd in efforts and investments from other players.
- **Sectoral Coordination:** Agriculture and its related elements cut across many ministries. As the lead institution, the Ministry of Agriculture, Livestock and Fisheries has a role to coordinate the activities and efforts of other relevant ministries in terms of good adaptation practices. The coordinating role would entail structuring the interventions of key ministries and agencies in a coherent manner in order to deliver national adaptation outcomes. This coordination could respond to harmonising different efforts in other sectors (forestry, fisheries, water and environment) within a set of adaptation goals as stipulated in the overarching policy framework under which the ministries and sectors are governed. Many commentators would argue that this role, in addition to policy making, defines the effectiveness of the government institutions in responding to climate change in any country.
- **Initiating and Leveraging Investments:** As part of providing enabling environment to support adaptation within the agriculture sector, the government might need to provide upfront investments in developing specific adaptation measures— especially, investments that concentrate on the country’s most urgent and immediate needs. Such investments from the government could leverage numerous international initiatives and financing mechanisms aimed at assisting countries with climate change adaptation. To a large extent, these investments could demonstrate government’s leadership to other actors involved in the adaptation agenda in the country.
- **Fostering Cooperation and Partnerships:** As the focal point of the country at international conventions, the government has an institutional role of fostering new cooperation and partnerships with international and local partners to harness technical, financial, institutional and managerial resources to support local adaptation initiatives.

The private sector, both indigenous and foreign, has a dominant role to play in the realisation of the overarching government policy of categorising agriculture as business through making the necessary investments to significantly lift agricultural production in Kenya. The Private Sector has the requisite experience, skills, structures and financial resources to scale up agriculture from its present subsistence level to industrial scale mechanised practice. It has the ability and incentive to champion innovation since that ensures marketability and profit. Specific roles for the private sector include the following (Box 2).

Box 2. Role of the Private Sector in Mainstreaming Climate Change Adaptation

- **The Private Sector** should be encouraged to take full advantage of the favourable enabling environment— economic, social and political— afforded by the Agricultural Transformation Agenda to engage in scaling up practices if Kenya must attain significant production levels whether it is in export high value crops, local staples, livestock or fisheries.
- **Public–Private Partnerships (PPP)** are likely to succeed and flourish when the Private Sector under a coordinated private engagement, is a viable partner both in terms of sourcing technology as well as injecting additional resources into agriculture.
- **Public-Private–Community Partnerships (PPCP)** are even more desirable as they have the added benefit of lifting the smallholder farmers in a series of catalysing relationships that will assist them to gain access to inputs, insurance and micro-credits. But, perhaps even more importantly, PPCP can link smallholders to viable markets, thereby transforming the rural economy while achieving food security and sustainable development anchored in agriculture.

8.3. Civil Society Organisations

The civil society organisations (CSOs) include a range of international, national and local actors working at different levels of functions depending on the area of interest. They may include local NGOs, conservation groups, media houses, religious organisations, gender-based social groups, trade unions and community institutions. In the context of climate change adaptation, CSOs provide diverse important functions as indicated in Box 3.

Box 3. Role of CSOs in Mainstreaming Climate Change Adaptation

- **Policy Advocacy:** Advocating for policy design and/or implementation for providing robust and coherent response to climate change is often the core function of the civil society. From experiences, CSOs are able to bring the attention of other institutions, especially the government to the climate challenges confronting the population and the agricultural sector. Through their networks, CSOs over the years have become powerful voices in leading national consciousness on climate change awareness, on policy choices that address the issues, as well as on mobilising the required resources to effect policy change.
- **Conduit for Local Voices and Operations:** As voices for local communities, CSOs often bring to national attention the diverse climate challenges that local communities are facing in their everyday life. In their own way, CSOs support development of local adaptation practices, especially related to alternative farming practices, diversifying livelihood portfolios, use of indigenous knowledge in developing coping mechanisms. CSOs are considered to be much closer to the agricultural communities who actually make adaptation decisions on the ground. CSOs and their networks collaborate with other institutions such as development partners, research communities and the government, to provide large-scale support to agricultural communities through, for example, extension services and market development of high-value farm products. Even where these services are provided outside the domain of climate change, they have been effective in enhancing adaptive outcomes of millions of people in Kenya through improved food security, agricultural innovation, increased household income and welfare.
- **Local Implementation:** Designing a national policy on adaptation is not enough, notwithstanding how most appropriate it might be. Local implementation of adaptation choices and options is extremely vital for adequately responding to climate change. A policy on provision of drought-tolerant seedlings must be accompanied and sustained by local adoption and practice for adaptation outcomes. An increasing role of the CSO institutions is their capacity to bridge policy systems at national level and implementation systems at local levels. CSOs are able to support this policy implementation with elements of capacity building through trainings, on-the-farm skill development, and practical demonstration with local farmers.

8.4. Regional Organisations

Regional organisations are supra-national organisational institutions that often function at the national level to promote regional approach to solving a common problem. These organisations cut across important sectors such as economy, security or infrastructure. Examples include: East African Community, Inter-Governmental Authority on Development, Common Market for Eastern and Southern Africa. They may also exist in order to manage a common pool resource that is trans-boundary in nature, e.g. forests, water resources or even agricultural land.

8.5. Development Partners

Development partners include a broad range of actors involved in providing technical, financial, institutional, and managerial functions in virtually all sectors, either as representatives of another country or as global community. Examples include: bilateral partners, development banks, intergovernmental organisations, and United Nations' agencies. In terms of climate change support, many of the partners are at the forefront of providing vital services to the Kenyan agricultural sector (Box 4).

Box 4. Role of Development Partners in Mainstreaming Climate Change Adaptation

- **Financing opportunities:** Many development partners working on climate change and other related issues, including United Nations Development Programme, United Nations Environment Programme, World Bank, African Development Bank, and Food and Agriculture Organisation of the United Nations have at different times and scales undertaken investments in the agricultural sector. Funding opportunities emanating from these organisational institutions have supported macro policy development on climate resilience to facilitating micro policy implementation. Development partners are able to leverage on their wide range of expertise to collaborate with multiple stakeholders in delivering adaptation services beneficial for income generation and improved welfare of Kenyan farmers.
- **Knowledge/Programme Management:**– Most importantly, development partners function as conduits for harnessing global and local knowledge useful for good adaptation practices in the agricultural sector. They are able to support the design of knowledge systems that can fit into local technologies for adaptation purposes. Managing adaptation programs by providing the required technical and managerial oversight is core to their work in many developing countries, including Kenya. Moreover, as development work is at the heart of their operations and mandate, development partners are often able to get the political buy-in of government institutions in accentuating adaptation priority in development planning.
- **Policy Advocacy:** Many development partners have been advocating for policy change for economic and social development, including infrastructure development in Kenya for years. Where successful, this advocacy function has supported the mainstreaming of climate change adaptation into national development planning, albeit less obvious. Additionally, in many cases, other non-state actors, particularly civil society and research institutions, have networked with many development partners in order to have government institutions accord significant policy attention to the issues of climate change adaptation. A few examples might include workshops organized by development partners and civil society on the impact of low education, information and human capital as limiting factors to smallholder development in Kenya. Like the civil society networks, the international and donor organisations in Kenya, such as the UNDP, the World Bank, the German Heinrich Boellman Foundation and the British Council, see themselves as a stimulating force in the process; because, they finance training and education programmes and other climate-related projects, with particular emphasis on adaptation.

For Kenya's National Climate Change Action Plan (NCCAP) to be fully and effectively implemented, a sound and enabling policy, legislative, and

institutional framework must be in place. In the absence of such a framework, substantial obstacles will emerge in translating the identified priority actions into implementable initiatives with tangible climate change benefits. Regarding the institutional arrangements, key aspects that need to be addressed include the need for clarity in roles and functions, the overlapping mandates, as well as institutional capacity and related enforcement capability of many institutions that perform climate change-related functions. Importantly, the identified institutional concerns cut-across almost all sectors, impact on the effectiveness of regulation, and addressing them requires substantial investment in financial and human resources. Institutional reform is therefore needed to establish a framework that coordinates and mainstreams climate change response across government, achieves policy integration and provides authoritative direction to achieve implementation of priority sectoral actions.

The NCCAP (GoK 2013b) proposed a comprehensive institutional and mainstreaming framework, with defined roles and responsibilities which would allow for the mainstreaming of climate change in Kenya. The proposed framework, illustrated in Figure 3 captures the need to respond to climate change in the context of the devolved government system in Kenya. All Government ministries, departments and agencies will have a role in mainstreaming climate change across their functions and processes. Therefore, the group of institutions featuring in Figure 3 is not exhaustive. However, the Ministry responsible for climate affairs is a fundamental leader for climate change mainstreaming to be successful. This Ministry, in consultation with all relevant actors, will need to develop a coherent stand-alone Climate Change Policy building on the NCCAP process that will frame and articulate Kenya's response to climate change.

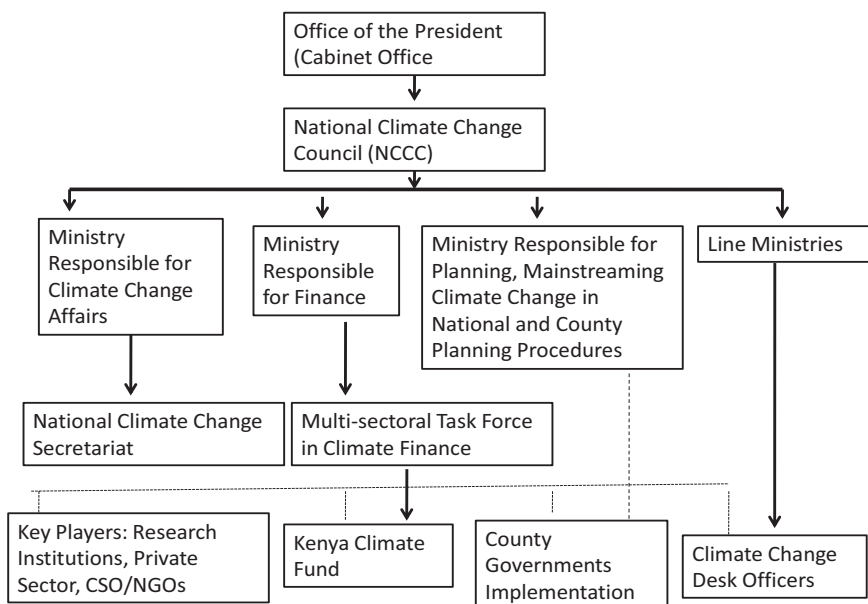


Figure 3. Proposed Climate Change Institutional Structure

SOURCE: NCCAP (2013b, 99)

10. Conclusion

Mainstreaming climate change adaptation in agricultural planning and development in Kenya should be approached from the standpoint of necessity in the context of sustainable development with greater emphasis on the generally accepted principle that food security, poverty eradication, economic empowerment, and social stability and development constitute the first and overriding priorities of a developing country like Kenya. The concept of a low-carbon economy as an underlying strategy to mainstreaming adaptation into agricultural planning and development calls for a new development paradigm that ensures simultaneously, a robust economic growth and an increase in climate resilience.

As the links between climate change and agriculture become better understood in the scientific community, public policy efforts to support agricultural adaptation and mitigation have intensified. Kenya has responded to the challenge by developing climate change response policy. This report has reviewed the process of Kenya's experiences and draws lessons for future national policy and institutional development in support of climate-smart agriculture. The concept of climate-smart agriculture describes agricultural systems that provide not only agricultural production,

but also climate change adaptation and mitigation benefits, and improved watershed and ecosystem management. To support climate-smart agriculture, policy and financing will need to adapt so that these multiple objectives of adaptation and mitigation as well as rural development, food security and ecosystem services can be achieved simultaneously.

With three quarters of Kenya's population dependent on agriculture for their livelihoods, it is a country in need of climate-smart agriculture. Kenya's NCCRS is the framework for integrating climate concerns into development priorities, government planning and budgeting. The NCCRS includes indicative budgets and plans for line ministries. The budget requires close to 20% of Kenyan government expenditures planned for agriculture annually for the next 20 years. Technologies/innovations for adapting to and mitigating climate change are available and clearly articulated in the policy documents. Policy implementers, NGOs, research institutions and farm households are aware of them. A number of the interventions have been implemented by the smallholders, not as deliberate climate change adaptation and/or mitigation strategy but as normal routine livelihood system. More often than not, the interventions are undertaken on small farm-level scales. Complete and widespread adoption of these strategies and innovations are limited by a number of factors:

- high cost of the technologies;
- existence of counterfeit technologies and the inability of the farmers to draw distinctions;
- small land sizes which make adoption of the technologies uneconomical;
- lack of market for the products; and
- lack of the requisite infrastructure for technology uptake.

As policy makers in Kenya anticipate the country's economic prospects, they must consider climate change challenges and agricultural adaptation. A range of "necessary options", such as providing farmers with seeds, fertiliser and financial and extension services to "sufficient options", such as developing new agricultural technologies and research into climate resilient crop varieties, is possible. Those concerned with economic growth and food security should identify and pursue responses best adapted to the country. Although, the NCCRS and NCCAP are important processes, there is need to develop adaptation and mitigation on different tracks, even in agriculture where many of the activities provide benefits for both. The separation of these processes is important for planning purposes and is necessary in order to access different streams of funding. Caution must, however, be exercised to avoid inefficiencies due to the promotion of similar activities. Overall, there is a growing consensus among all stakeholders that climate change must be addressed in an integrated manner with adaptation and mitigation. The growing population will need options for addressing adaptation in local sub-sectors. These options must aim at increasing food supply. This means that the Climate Compatible

Development (CCD) concept needs to be mainstreamed in a balanced manner. Hence, in order to achieve food security goals, it will require building not only effective but also strategic partnerships that aim at a systematic development and implementation of CCD initiatives.

Notes

1. Adaptation in the context of climate change has been defined as “an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities” (IPCC 2001, 982).
2. The Climate Change Bill proposes a National Climate Change law and policy for Kenya. Once it is passed into law, the legislation will enhance coordination and implementation of climate change resilience. It will also advocate for low carbon development for sustainable development of the country.

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CHAPTER TWO

Climate-Smart Agriculture in Lesotho: Initiatives and Perspectives

Patrick Gwimbi

Abstract

Climate-smart agriculture (CSA) has emerged as a framework for promoting agricultural systems that simultaneously increase productivity and resilience against climate change, and provide greenhouse gas mitigation benefits. However, the discourse surrounding it is fraught with hyperbolic expectations and rhetoric as its implementation has raised several questions, including the extent to which its interventions are reaching the intended targets, achieving desired goals, and whether there are enabling policies within countries where it is being implemented. This chapter assesses CSA initiatives in Lesotho in terms of policy and implementation. Based on literature survey including documents, scientific publications, and project reports from relevant government and donor-funded programmes, major CSA policies and practices are examined. To complement desk reviews and verify literature findings, key stakeholder consultations were held. The key findings show that, in general, CSA policy intents exist in Lesotho. Conservation agriculture, homestead gardens and Machobane farming system, for example, are driven by the agricultural policy and supported by development partners. CSA programmes are, however, not sufficiently up-scaled nationally beyond those supported by donors. Responses to climate change also need to include fundamental changes to policies that constrain women's participation in climate-smart agriculture initiatives. Gender disparities in the national Constitution restrict women to secondary land rights, meaning that they hold these rights through male family members, though improvements in sectoral policies are acknowledged. The study, however, notes that sectoral policies are still undermined by some clauses in the national Constitution. The findings also suggest that, while CSA can improve crop yields at household level, inputs and labour constraints remain major limits to its wide adoption in the absence of external support. The presence of some successful CSA initiatives, however, suggests that opportunities exist. Government partnership with development partners remains an important component of CSA strategies.

Keywords: Climate-smart agriculture, conservation agriculture, greenhouse gases, Lesotho, policy

1. Introduction

Climate-smart agriculture (CSA) has attracted substantial attention, spurred by hopes of its potential to increase productivity, resilience of farming systems to climate impacts, and mitigate climate change through greenhouse gas (GHG) emission reductions (FAO 2011). However, despite these efforts, adoption levels remain low in Southern Africa with less than 1% of arable land under CSA (Hove *et al.* 2011). One of the greatest challenges facing policy makers today concerns the extent to which CSA interventions are achieving their intended targets and goals and whether there are enabling policies within countries where it is implemented.

For Lesotho, ensuring food security remains a key development challenge for a country adversely impacted by climate change (FAO 2011; African Technology Policy Studies Network— ATPS 2013; Gwimbi *et al.* 2013). Increasingly, incidences of crop failure due to adverse droughts, hailstorms and early frosts, and land degradation have been reported with serious implications for human wellbeing (FAO 2011). The rural population, which constitutes 77% of the country's approximately two million people, faces prospects of tragic crop failures, reduced agricultural productivity, increased hunger, malnutrition, and diseases (BoS 2015). At the same time, many agricultural practices are directly responsible for damaging the environment and are a major source of anthropogenic GHG emissions (Lamboll *et al.* 2011). With the impacts of climate change being felt on food systems, and the contribution of GHG emissions also gaining attention, CSA is one of the sustainability pathways at the heart of policies being pursued to address these challenges.

The crucial and relevant question today is what CSA policies exist in Lesotho in the face of climate change threats — a question this chapter tries to answer. Proponents of CSA claim that practicing CSA policies results in: (1) increased yields, (2) reduced vulnerability to climate change, and (3) reduced GHG emissions (Behnassi *et al.* 2014; Campbell *et al.* 2014). However, a growing body of literature on the impact of climate change on agriculture in Lesotho is not matched by an equivalent understanding of CSA policy responses across different sectors. As such, CSA responses and their challenges need to be investigated.

Because climate change is a global issue, a growing number of global actors, such as the United Nations Framework Convention on Climate Change (UNFCCC), the International Fund for Agricultural Development (IFAD), the World Bank, and the Food and Agriculture Organisation of the United Nations' (FAO) have endorsed CSA as an agenda aimed at addressing the impacts of climate change (Bernard *et al.* 2013). The UNFCCC, in particular, committed itself to address climate change in an integrated and holistic manner by implementing national programmes for adaptation and mitigation to climate change. Variances, however, exist between global and national commitments

In Lesotho, several studies indicate that climate change is already taking place with adverse impacts (BoS 2015). CSA is being promoted as a solution to address impacts of climate change threats on agriculture and as a means of preventing erosion and maximising the ecological functions of the soil. However, despite these efforts, little has been documented on prevailing CSA policy initiatives and their adoption by farmers. This chapter attempts to fill this gap by exploring CSA policy and practice initiatives in Lesotho.

The specific objectives of this chapter are to: (i) examine key CSA policy initiatives in Lesotho, (ii) analyse possible ways being engaged in support of CSA policy initiatives, and (iii) examine the linkages between CSA policies and practices.

In the subsequent section, a review of literature on the trends in Lesotho's agricultural production is made. This is followed by a conceptual framework used to examine CSA initiatives. The study is based on sustainable livelihoods framework. That is followed by sections that outline the methods used to collect data and results. The final section presents conclusions and makes some recommendations.

2. Trends in Agricultural Production in Relation to Climate Change in Lesotho

Food security is a challenge in Lesotho where the proportion of undernourished people is estimated at 15.7 per cent (Africa Food Security and Hunger/Undernourishment Multiple Indicator Scorecard 2014). The country's main food crops (maize, sorghum and wheat) accounting for 85% of the country's cereal production (GoL 2000) are under threat from climate change. Maize and sorghum are grown throughout the country in summer (October to April). Winter wheat is common in the Mountains (May to September).

Maize production has decreased almost four-fold, from 6 million tonnes/year in 1969 to 2 million tonnes in 2012. Simulations using estimates suggest that the detrimental changes in climate since the 1960s can account for a substantial decline in agricultural production (Figure 1). Production has consistently declined since 2004–2005 (Billingsley *et al.* 2013). The main reason for declining staple food production, particularly maize, shown in Figure 3.1 is climate change and variability (GoL 2012). Between 1999 and 2009, maize production decreased by 54 per cent. Maize yield per hectare for 2013/2014 was 0.59 million tonnes/ha, showing a decrease of 28.0 per cent compared to 0.82 million tonnes/ha of the previous year (BoS 2015).

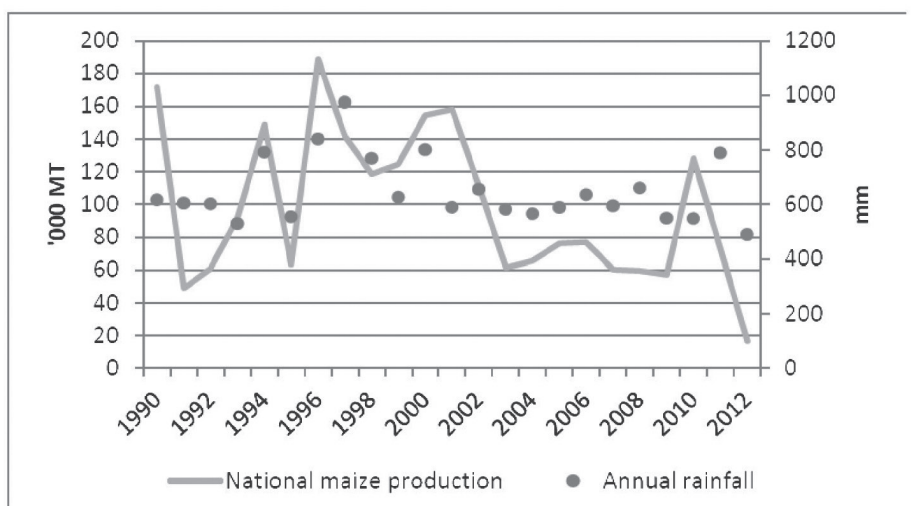


Figure 1 Trends in Lesotho's maize production compared with estimated average national annual rainfall, 1990 – 2012

SOURCE: FEWSNET (2013)

While crop production has declined over the years, land area lying fallow has increased over the past five years (Figure 2). Major forms of land use in Lesotho are agricultural and pasture land. Drivers for these land use changes are delayed rainfall and early frost onset (BoS 2012).

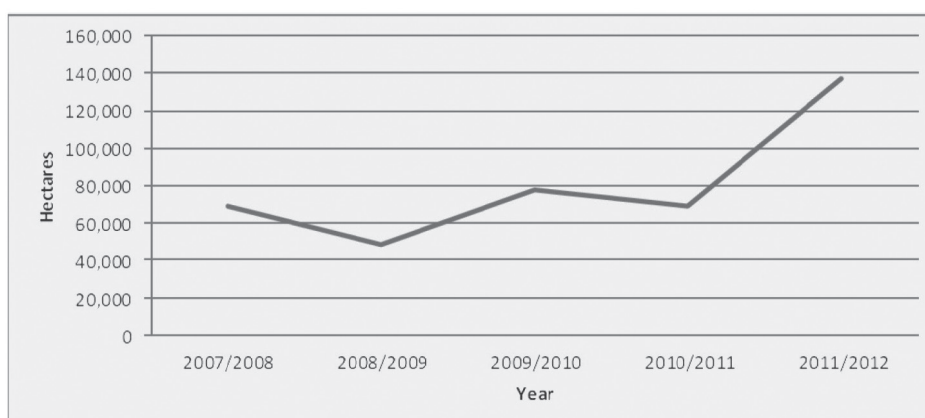


Figure 2 Trends in arable land lying fallow over years

SOURCE: GoL (2012)

A number of other factors that constrain agriculture have, however, also been reported in literature. These include declining soil fertility, poor agricultural production technologies and practices, uncontrolled grazing

and the associated deterioration in the quality of rangelands, lack of capital and irrigation facilities, and disease outbreaks in case of livestock production (GoL 2012). Loss of manpower due to HIV/AIDS and ineffective agricultural management practices in the face of climate risks also play a role in the declining agricultural production in Lesotho (FEWSNET 2013).

3. Conceptual Framework

The conceptual framework presented in this chapter was informed by four main observations. The first observation is the recognition that agriculture plays an important role in the socio-economic development of many developing countries. Second, despite its importance, the level of agricultural productivity in Lesotho is not only low but declining in many instances, resulting in increased food insecurity and poverty. This situation is worsened by climate variability and climate change, whose impacts are more pronounced in rural areas (Billingsley *et al.* 2013, Rosenzweig and Parry 1994). Third, agriculture is not just a victim of climate change; it also contributes to climate change by way of GHG emissions. Fourth, agriculture is characterised by complex social, economic, and environmental interactions. Taken together, these observations underline the importance of investing in policies that address these challenges (Ren 2015).

Climate-smart agriculture is a recent concept and approach launched by FAO in 2010 in response to the growing need for clear and coherent strategies for managing agriculture and food systems under climate change. CSA operates on the principles of integrated management with explicit incorporation of adaptation and mitigation goals along with improvements in food security, rural livelihoods, biodiversity conservation, and ecosystem services (Harvey *et al.* 2014). Such approaches are driven by the goal of ensuring resilience, productivity, and sustainability with emphasis placed on adaptive management, stakeholder involvement, and the simultaneous achievement of multiple objectives (Behnassi *et al.* 2014). According to FAO (2010), CSA strives to attain three objectives: 1) sustainably increasing agricultural productivity to support equitable increases in incomes, food security, and development; 2) adapting and building resilience to climate change from the farm to national levels; and 3) developing opportunities to reduce GHG emissions from agriculture compared with past trends. To do so, it needs to combine practices, policies, institutions, as well as finances.

A wide range of proven practical interventions such as those captured in Box 1 are part of CSA (Behnassi *et al.* 2014). Available literature shows that such interventions have long been applied in several countries in an attempt to offset the negative impacts of climate change on agriculture (AGRA 2014).

Box 1. Examples of Climate-Smart Agriculture

Conservation Agriculture: efficient use and conservation of resources through minimal mechanical soil disturbance and maintenance of mulch of carbon-rich organic matter; involves: (i) permanently minimising or avoiding mechanical soil disturbance (no-till seeding); (ii) maintaining a continuous soil cover of organic mulch with plants (crop residue, stubble and green manure/cover crops including legumes); and (iii) growing diverse plant species in the cropping systems (Kassam *et al.* 2014).

Homestead or keyhole garden: raised-bed made up of layers of soil, ash, manure and other organic material that retains moisture and nourishes the soil, making it more productive than a conventional garden, even during dry or cold months (Billingsley *et al.* 2013).

Agroforestry: a collective name for land-use systems in which woody perennials (trees, shrubs, etc.) are grown in association with herbaceous plants (crops, pastures) or livestock, in a spatial arrangement, a rotation, or both; there are usually both ecological and economic interactions between the trees and other components of the system (Lundgren 1982).

Improved grazing land management: increased cover of high-productivity grasses and overall grazing intensity, nutrient management, fire management, and species introduction; reduces greenhouse gas emissions (Grieg-Gran 2010).

Water harvesting: improve efficiency and conservation of moisture, and reduce soil loss reduction through ex and in situ water harvesting (Grieg-Gran 2010).

A key issue about CSA is livelihood and income diversification potential at household level. This chapter is guided by the Sustainable Livelihoods Framework as a conceptual and interpretive lens in assessing how CSA is practiced in Lesotho.

3.1. Sustainable Livelihoods Framework

The conceptual framework used in this study is adapted from the Department for International Development (DFID). The general goal of the framework is to alleviate poverty in rural communities (DFID 1999). Chambers and Conway (1992, ?) define sustainable livelihoods as comprising of: “... *capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base*”

Three key features in the sustainable livelihood framework addressed in this chapter are livelihood assets, strategies, and outcomes. The livelihood assets are the resources on which people draw in order to carry out their livelihood strategies (Farrington *et al.* 2002). The assets in the DFID framework were adopted in this research, namely, natural, physical,

financial, human, and social capital (Box .2). The argument in the literature, from a CSA perspective, is that access to land, water resources, and other essential assets represents the foundation for sustainable livelihoods in the fight against poverty in rural areas (van Marrewijk 2011).

Box 2. Different types of assets

Natural capital: land, water, trees, genetic resources, livestock, soil fertility

Physical capital: agricultural inputs, business equipment, houses, consumer durables, vehicles and transportation, water supply and sanitation facilities, and communications infrastructure

Human capital: education, skills, knowledge, information, health, nutrition, time, labour

Financial capital: savings, credit, and inflows

Social capital: membership in organisations and groups, social and professional networks

Political capital: citizenship, enfranchisement, and effective participation in governance

SOURCE: Goh (2012, 2)

Policies and institutions influence access of households to livelihood assets (DFID 2000). Bingen (2000) groups the institutions into cultural, community, social, collective and policy- or governance-related based on legislature and regulations. To this end, the institutional arrangements at different scales need to be assessed as they play an important role in ensuring the sustainability of livelihoods in the face of climate change threats. Effectively, they determine access to items, such as capital, livelihood strategies, and decision making bodies.

The literature on the gendered¹ implications of climate change on agricultural economies underscores how gendered division of labour and responsibilities can create differentiated and distinct vulnerabilities at varying scales. Gender dimensions of vulnerability to climate change often result from differential access to social and environmental resources needed for adaptation. In many agricultural economies, women usually have poorer access than men to financial resources, land, education, health and other basic rights (Opondo and Nyasimi 2015). The implications of these findings underscore the importance of integrating gender in the design of any response that seeks to tackle climate variability and change-related vulnerabilities among agricultural communities (Opondo and Nyasimi 2015).

Research has also shown that access to inputs and/or control over resources between men and women farmers can significantly affect food security in the household (Beuchelt and Badstue 2013). Otzelberg (2012) concurs with

this view, arguing that, if CSA is to be effective, then its efforts need to be gender-responsive, taking into account the specific needs of men and women and the gendered inequalities that may compound women's access to benefits addressing climate change impacts.

Recognising gender differences in CSA can enable gender-sensitive responses that reduce vulnerability of men and women. Gender inequalities in land rights globally have been blamed for women's lower access to land than men, particularly in Africa (FAO 2010). Thus, interventions that are not sensitive to gender dimensions and other drivers of social inequalities risk reinforcing existing vulnerabilities (Opondo and Nyasimi 2015).

The conceptual framework used in this chapter illustrates how policies and institutions influence CSA. CSA could strengthen the natural asset base for rural households, thereby improving their adaptive capacity to climate change. The different indicators discussed above are examined in this chapter to assess their contributions to CSA initiatives.

4. Methods

The study area is Lesotho, a Southern African nation completely surrounded by the Republic of South Africa. The country is demarcated into four agro ecological zones: Lowlands, Foothills, Mountains and the Senqu River Valley. The Lowlands are defined by their relatively high rainfall that allows cultivation of maize, sorghum, beans, winter wheat, and vegetables. The Foothills receive lower rainfall compared to the Lowlands. They rise from 1800 to 2400 meters above sea level. Maize, sorghum, and summer peas are grown in this zone. The Mountains rise to an elevation of 3500 meters and constitute by far the largest and least densely populated portion of the country, and they are characterised by very cold winters. Livestock, wheat, and peas are the main agricultural activities in this zone. The Senqu River Valley runs from east to west across the country. The valley is characterised by a low rainfall. Winter wheat and maize are grown in the valley.

Agriculture contributes 8.6% of the GDP and remains the main source of employment and sustenance for the majority of the rural population. Decades of drought have, however, become increasingly common in recent years, undermining rural agricultural production and eroding rural households' livelihoods (Billingsley *et al.* 2013).

To understand existing CSA initiatives in Lesotho, a combination of desk and key stakeholders consultations were carried out. The study first analysed documented policies and practices related to CSA in Lesotho. The desk study aimed to generate information about existing CSA-related policies and practices. These included the Constitution, land, gender, water, agriculture, environment and forestry. Literature including published references as well as research reports from relevant national and donor-funded research projects was scrutinised. Scientific papers were also

identified and assessed in addition to all the other documents. Studies with a limited data or applying questionable methods in data collection were not considered.

From each studied document, the relevant CSA aspects were extracted, the conditions they applied to recorded, as well as any uncertainties raised. The reviews produced a fact sheet about the main drivers of CSA in Lesotho. Thereafter, based on the desk study findings, key stakeholders to CSA were identified for further consultations.

The review of documents and scientific literature on CSA produced stakeholders that were consulted on the desk study findings and other outstanding issues related to the study objectives. An all-stakeholder-consultation one-day workshop was organised and the draft report of the desk review findings presented for validation. A total of 30 key stakeholders attended, representing government sectors (Agriculture, Bureau of Statistics, Communications, Economic Planning and Development, Forestry and Land Reclamation, Water, Natural Resources and Energy, and Lesotho Meteorological Services), Civil Society Organisations, Private Sector Foundation of Lesotho, the media, non-governmental organisations (NGOs), National University of Lesotho (departments involved in or affiliated with agriculture), Lesotho College of Agriculture, donor organisations such as World Vision, United Nations Development Programme (UNDP), and the Natural Resources Policy Analysis Network (FANRPAN).

5. Results and Discussion

5.1. International and Regional Drivers of Lesotho's Climate-Smart Agriculture Policy Initiatives

The Government of Lesotho recognises its vulnerability to climate change and the need for global cooperation in addressing climate-change-related challenges. It endorsed the UNFCCC in 1992 and ratified it in 1995 (GoL 2007). Being party to the UNFCCC has resulted in the country undertaking certain mandatory activities associated with its obligations under the convention. These include participation in UNFCCC processes, developing and submitting communications, carrying out greenhouse gas inventories, and developing a National Adaptation Programme of Action (NAPA) (Chishakwe 2010). The country has also benefited from multilateral funding currently supporting climate change adaptation projects aimed at keeping farmers ahead of the climate change challenges.

Lesotho submitted its First National Communication to the UNFCCC in 2000. The First National Communication details climate change impacts, and adaptation and mitigation options in eight sectors deemed vulnerable to climate change, namely: water, agriculture, rangelands, forestry and biodiversity, soils, health, and Basotho culture (GoL 2007). The country submitted its Second National Communication (SNC) to the UNFCCC in

November 2013. The communication includes the country's greenhouse gas inventory, impacts and vulnerability, and policies related to climate change mitigation, adaptation, research and public education.

The Seventh Conference of the Parties (COP) of UNFCCC held in Marrakech in 2001 acknowledged the specific situations of least developed countries (LDCs) (that they do not have the means to deal with problems associated with adaptation to climate change) and established an LDC-funded work programme (Meybeck *et al.* 2012). Recognising that LDCs are among the most impacted by adverse physical impacts of climate change, the UNFCCC established NAPAs as a dedicated, harmonised, and country-led process for such countries to identify priority activities that respond to their urgent and immediate needs to adapt to climate change (Meybeck *et al.* 2012). According to Article 4.9 of the UNFCCC (UNFCCC 2001):

The Parties shall take full account of the specific needs and special situations of the least developed countries in their actions with regard to funding and transfer of technology.

The NAPAs focus on a country's urgent and immediate needs, for which further delay could increase vulnerability to climate change (Meybeck *et al.* 2012). Lesotho is one of the beneficiaries of COP. Following the adoption of the First National Communication and its guiding principles, Lesotho formulated its NAPA, outlining the country's adaptation priorities (Table 1). The key adaptation needs were derived through multi-stakeholder consultations involving the government, the private sector, National University of Lesotho, NGOs, civil society organisations, and local communities.

Eleven specific prioritised NAPA options, developed through a consultative process, are shown in Table 1. The criteria used to rank priority areas included the most urgent needs, taking into account the vulnerability of sectors, vulnerability of groups, and the contribution to food security and to poverty reduction, and economic cost (Meybeck *et al.* 2012).

Lesotho has also signed other climate-change-related United Nations conventions, including:

- United Nations Convention on Biological Diversity (UNCBD);
- United Nations Convention on Combating Desertification (UNCCD);
- Principle 17 of Rio Declaration requiring environmental impact assessment of activities likely to affect the environment;
- World Commission on Environment and Development (WCED), article 5 on legal principle for environmental protection and sustainable development;
- New Partnership for Africa's Development (NEPAD) Framework Document requiring states to develop strategies for sustainable development;

- United Nations Millennium Development Goals (MDGs), which aim to address environmental issues linked to poverty (such as water and sanitation) as well as ensuring biodiversity protection.

Table 1 Lesotho's list of prioritised climate change adaptation options

Option	Title
1	Improving Resilience of Livestock Production Systems under Extreme Climatic Conditions in Various Livelihood Zones in Lesotho.
2	Promoting Sustainable Crop-Based Livelihood Systems in Foothills, Lowlands, and the Senqu River Valley.
3	Capacity Building and Policy Reform to Integrate Climate Change in Sectoral Development Plans.
4	Improvement of an Early Warning System against Climate-Induced Disasters and Hazards
5	Securing Village Water Supply for Communities in the Southern Lowlands
6	Management and Reclamation of Degraded and Eroded Land in the Flood-Prone Areas (Pilot Project for Western Lowlands)
7	Conservation and Rehabilitation of Degraded Wetlands in the Mountain Areas of Lesotho
8	Improvement of Community Food Security through the Promotion of Food Processing and Preservation Technologies
9	Strengthening and Stabilising Eco-tourism-Based Rural Livelihoods
10	Promoting Wind, Solar and Biogas Energy Use as a Supplement to Hydropower Energy
11	Stabilising Community Livelihoods which are Adversely Affected by Climate Change through the Improvement of Small-Scale Industries

SOURCE: GoL (2007)

The Government of Lesotho has further endorsed regional CSA-related principles such as the Southern African Development Community (SADC) declaration on gender and development adopted by heads of state in August 2007; the Convention for the Elimination of All forms of Discrimination against Women (CEDAW) and the protocol to the African Charter for Human and People's Rights on the Rights of Women in Africa (GoL 2007); Policy and Strategy for Environment and Sustainable Development, and the African Ministerial Conference on Environment (AMCEN), and other similar programmes.

The international and regional drivers of CSA show that agriculture is very prominent as most of the initiatives are directly related to the agriculture sectors. The broad range and various ways to increase the resilience of agriculture constitute a valuable base from which the country identifies priority areas of work and of research in order to better answer the needs of

the most vulnerable. They also provide a database of measures that is used to prepare some policies and plans needed to address climate change issues. The NAPA priority areas also give strategic direction and guide Lesotho's development partners in implementing CSA-related programmes. Several NGOs in Lesotho, for example, have been implementing climate change adaptation activities within the framework of NAPA priorities, including the promotion of conservation agriculture and keyhole gardens.

5.2. Review of Current Policies Impacting Climate-Smart Agriculture

5.2.1. Land Tenure and Gender Policies

Land is a major resource in Lesotho. The land policy is, therefore, key when it comes to CSA, given that all activities have to be implemented on land. Various researchers have examined Lesotho's land policies over the years to try and understand how it impacts on all farmers' access and use of land resources for agricultural productivity (Mosaase 1986, GoL 2000, African Development Bank Report 2005). In all these research reports, gender disparities in land access are highlighted and remain significant.

Land ownership in Lesotho is prescribed in the Constitution, which stipulates that all the land belongs to the king and is held in trust by all Basotho male heads of household (Maro 2011). The Constitution prohibits gender discrimination in general but recognises exceptions on issues relating to marriage, divorce, and female inheritance where customary law is supreme. For example, Section 18 (4) (c) of the Constitution of Lesotho gives priority to customary law, which relegates women to being legal minors: under their fathers, husbands, and sons or male relatives. Even where women inherit property, social norms dictate that they waive their inheritance rights in favour of their male counterparts in order to ensure support and protection in the event of divorce or abandonment by their husbands (Maro 2011). Maro (*ibid.*) reports that in the event of traditional biases, women have difficulty in asserting their rights in land disputes. The Land Commission Report of 2000 acknowledges this disparity and recommends amendments to such sections of the Constitution (GoL 2000).

The Land Act of 2010 is one of the sectoral instruments aimed at establishing greater land tenure security for all land occupants against arbitrary land seizure and at enhancing gender equity in land ownership and land transactions. It establishes a simplified framework for systematic land registration and establishes a new land administration authority (LAA) that is autonomous in its operations. It also provides efficient and cost-effective land administration services to public and private users. However, while some researchers have complimented the Government of Lesotho for reforming its land tenure to remove serious constraints imposed by the customary laws on agricultural development, the national Constitution still retains clauses that override such reforms as highlighted above.

Crucially important to CSA is also Lesotho's gender policy, which calls for equal access to and control over resources such as land and credit. The

policy advocates the allocation of land in accordance with availability, not in terms of gender. Women in rural areas, however, remain unaware of most of these reforms and their legal rights. Women also remain inadequately capacitated technically and financially to advocate for their legal land right. This situation continues to disadvantage women in the face of climate change threats.

5.2.2. Food Security Policy

Lesotho's Food Security Policy of 2005 is based on the pillars of: (a) improving food security; (b) reducing poverty; (c) sustainably conserving and managing the environment; (d) improving production efficiency; (e) improving income distribution; and (f) increasing agricultural sector contribution to the gross domestic product (GDP) (FAO 2013). The specific objectives are to: promote agricultural and food production; to ensure access to food through employment and effective policy monitoring; to promote infrastructure and services to support livelihoods; to promote public transfers and safety nets; to mainstream HIV/AIDS within food security policies; to manage commercial imports, food aid deliveries, and food stocks effectively; to promote improved household-level food utilisation; to develop improved food security and vulnerability information systems; and to strengthen institutional frameworks for implementing, evaluating, and monitoring food security measures.

The core contents of the policy on CSA are shown in Table 2. These objectives are to be achieved through coordinated short- and medium-term strategies and measures in the key sectors that influence the various dimensions of the country's food security.

Table 2. CSA-related policies in Lesotho's

Policy	CSA issues included
Food Security Policy 2005	The heart of the policy document is a set of 'strategic fields of action for food security': • promotion of Conservation Agriculture (CA) with the help of development partners through: Activities including (i) conducting and adopting technologies suitable to the local conditions; (ii) offering specialised CA training modules to Extension staff and farmer groups; and (iii) introducing subsidies for input for innovative approaches to CA; • promotion of block farming to increase food production by facilitating (not directly involved in operations) the promotion of block farming throughout the country; supporting agriculture extension systems; offering incentives through subsidies for innovative approaches preferable for innovative investments (irrigation equipment, tractors, etc. in line with agricultural subsidy policy); reforming the land tenure; • diversification of production for food security: the policy advocates substitution of more suitable crops and changing to the production of a greater variety of crops; promotion of the <i>machobane</i> farming system and other subsistent agricultural systems: efficient subsistence agriculture and indigenous farming systems; • promotion of homestead garden production (including keyhole gardens, trench gardens, and bag gardens that use organic fertilisers); • promotion of livestock production and improvements in range management activities including (i) supporting the combating of livestock theft; supporting rangeland productivity; (ii) promoting small stock production for poor vulnerable households; (iii) promoting intensive livestock and milk production in peripheral –urban areas; • promotion of land conservation and rehabilitation: the policy promotes cultivation practices (e.g., conservation farming) and physical protection measures (terraces or stone bunds) to prevent erosion; awareness creation and enforcement of physical measures for cultivation of slopes; • promotion of gully rehabilitation (stone barriers, afforestation measures and recultivation) and ownership in them during and after rehabilitation; and • promotion of research to support adoption to new technologies;

Policy	CSA issues included
National Irrigation Policy of Lesotho 2002 (Draft)	advocates for demand-led smallholder irrigated plots.
Plant Protection Policy of Lesotho 2002 (Draft)	promotes the use of environmentally-friendly and sustainable plant protection strategies to maximise agricultural productivity, quality of food and acceptance of imports by trading partners while reducing losses caused by pests. promotes protection of the natural environment from harmful impacts of invasive plant pests.
Livestock and Range Management Policy, 1994	Aims to achieve greater self-reliance and increased incomes for livestock owners while protecting and regenerating the underlying natural environment and resource base. The policy promotes: improved range carrying capacity by developing a comprehensive natural resource management programme; intensive livestock production in the lowlands and extensive production in the foothills and mountain cattle post grazing areas consistent with maintaining sustainable stocking rates and in consideration with other uses; the elimination of livestock transhumance from lowlands village grazing areas to foothill and mountain cattle post grazing areas to more equitably allocate available rangelands to livestock owners residing in mountain areas; cattle post adjudication of grazing rights within cattle post grazing areas (<i>lihlaba</i>) to better allocate the use of mountain rangelands to local residents; improved genetic characteristics of Lesotho Livestock; and enhanced levels of livestock nutrition by maintaining sustainable stocking rates and by expanding the fodder resource base.

The Food Security Policy of 2005 acknowledges the role played by donors in supporting agriculture. Critics have, however, argued against its over-reliance on external funding. As the global political and economic environment becomes more volatile, it may be difficult to attain some of the objectives.

5.2.3. Environmental Policy

The environmental policy of Lesotho starts with the Constitution of Lesotho, which deals contemporarily with the issue of both environment and environmental rights. Section 36 of the Constitution (1993) states that Lesotho:

shall adopt policies designed to protect and enhance the natural and cultural environment of Lesotho for the benefit of both present and future generations and shall endeavour to assure to all citizens a sound and safe environment adequate for their health and wellbeing.

The Constitution empowers parliament to make laws that provide measures intended to protect and preserve the environment from abuse, pollution, and degradation; to manage the environment for sustainable development; and to promote environmental awareness. The Constitution also recognises the need to shape the path to sustainable development by embracing principles of climate-smart agriculture, environmental protection, sustainable natural resource use, and conservation of biodiversity.

The National Environment Policy of 1998 generally aims at achieving sustainable livelihoods and development for Lesotho. The goal of the National Environment Policy is to ensure protection and conservation of the environment and sustainable development. One of the policy objectives is to ensure formulation of an environmental legislation. To this end, the policy was translated into a legal framework through the Environment Act of 2008.

The Environment Act 2008 provides for the management of the environment and all natural resources of Lesotho and for all connected matters. The National Environment Act includes the key features of the Rio Summit in 1992, such as Environmental Impact Assessment, Audits and Monitoring, Environmental Management, Environmental Restoration Order, and International Environmental Conventions.

5.2.4. Forestry Policy

Lesotho's Forest Policy of 2008 is rooted on poverty reduction and securing livelihoods through increasing tree cover on land area (indigenous and exotic), through engagement with individuals, groups, and private holdings; through educating the public on the values, purposes, and benefits of forestry; and through promoting the use of trees in support of conservation and production of both arable agriculture and rangelands.

The Ministry of Forestry and Land Reclamation, under the Forestry Policy, is responsible for implementing programmes, such as social forestry, which encourages the establishment of individual tree nurseries, from which government procures seedlings for wider application of the community woodlots (GoL 2008).

The establishment of woodlots is expected to arrest erosion and ensure adequate soil cover through the provision of canopy and re-establishment

of biodiversity (GoL 2008). In addition, the trees are expected to contribute to climate change mitigation as carbon sink tanks.

5.2.5. Water and Irrigation Policies

The role of water in food and livelihood security is a major issue of concern in the context of persistent poverty and continued environmental degradation (Bossio and Geheb 2008). In Lesotho, water is the most critical resource issue. Although there is considerable knowledge on the issue of water management, an overarching picture on the water–food–livelihoods–environment nexus is still low.

The Government of Lesotho sees irrigation as a key avenue for increased agricultural production and household food security as it would enable farmers to intensify and diversify their crop production base. The draft irrigation policy of 2002 calls on private sector involvement in supporting small-holder irrigation schemes. Irrigation policy also promises to address the specific difficulties which women face in irrigation.

Irrigation development has been largely unsuccessful due to a top-down and supply-driven approach on the part of the government and donors with little consultation with, or participation by, farmers (FAO 2005). Currently irrigation is mostly used in small schemes mostly on vegetables and using surface and sprinkler irrigation systems.

5.2.6. Gaps in Current Climate-Smart-Agriculture-Related Policies

At the broadest level, critics to Lesotho's CSA-related policies can be clustered around their sectoral nature and they also lack emphasis on issues of climate change in their frames. This points to the absence of a national climate change policy integrating different sectoral policies. The absence of a national climate change policy hinders Lesotho's climate change responses and initiatives. Under the UNFCCC, climate change policies need to be considered alongside those for other sectors in order to support sustainable resource use for efficient agriculture food supply chains which focus on the whole picture, and not just one sector (Chambwera and Murray 2013).

The government draws its development programmes with a strong leaning on donor support. As a result, key features of NAPAs remain on paper due to lack of funding and legislation support. CSA could perform better if it had a national policy, legal and budget support. Policy makers need to formulate legal frameworks that encourage investment in CSA-related practices. This constraint can be explained by the current scenario where CSA receives little or no funding from the national budget.

Gender-blind sections of the Constitution restrict women's decision making and limit their opportunities and sources of livelihoods and, thus, the technologies to be adopted under CSA. While efforts being made to address the imbalances through sectoral laws are acknowledged, even more important is the need to amend the gender discriminatory sections of the

Constitution and offer greater enforcement of policies and regulations that explicitly protect women against gender discrimination.

5.3. Adoption of Climate-Smart Agriculture by Smallholder Farmers

The Government of Lesotho, with the support of its development partners, has implemented several projects aimed at reducing poverty and contributing to greenhouse gas emissions reduction. This section provides information on some of the programmes initiated in the country.

5.3.1. Conservation Agriculture

Conservation agriculture (CA) (Box 3) emerged as a strategy to increase food security in an environmentally sustainable way. It is implemented with the support of various development partners (e.g. Food and Agriculture Organisation (FAO), Catholic Relief Services (CRS), World Vision Lesotho (WVL), Growing Nations, CARE-Lesotho, Serumula, Send a Cow Lesotho). WVL, for example, operates in seven of the ten districts of the country, namely: Maseru, Botha-Bothe, Mafeteng, Leribe, Berea, Mohale's Hoek, and Quthing (Mokitimi *et al.* 1992).

Box 3. Conservation Agriculture

Conservation agriculture (CA) is a farming system that has been practiced in Lesotho for about 30 years (Marake 2008). The system is commonly called "*likoti*", a Lesotho name for "basin agriculture". The method involves digging potholes that are approximately 20 cm across and 15 cm deep in a 75 x 75 cm grid-like pattern. Seeds are directly planted into each pothole along with some inorganic or organic fertiliser. In the following season, seeds are planted again in the same pits. Crop residues are retained and staple crops are rotated and/or intercropped. The *likoti* system has seemsa promising means of increasing yields and conserving soil and water resources (Silici *et al.* 2011).

In relation to the fertility of the soil, CA may increase the fixation of carbon (Fowler and Rockstrom 2001, Pedro *et al.* 2001), and this also has a positive impact on the greenhouse effect. If more carbon is fixed in soil under CA than under conventional tillage, CA fields can act as a sink of carbon and reduce the emission to the atmosphere.

FAO is supporting vulnerable households through CA with cover crops of wheat through resource centres covering all districts of Lesotho. CARE-Lesotho is engaged in teaching communities and supporting CA implementation in the districts of Quthing and Mokhotlong. CRS and Caritas are implementing the Mountain Integrated Conservation Agriculture (MICA), supporting conservation agriculture in the districts of Quthing, Mohale's hoek, and Mafeteng. The Rural Self-Help Development Association (RSDA) is also supporting CA and livestock integration where fodder cover crop is used for feed formulation.

Previous studies on CA confirm that the system results in increased household food security, and economic and social wellbeing. Field research

by Walker *et al.* (2014) at Maphusteng in Lesotho, between 2009 and 2013, demonstrates that yields of up to 8 tonnes per hectare or more have been achieved using CA. Elsewhere, Silici *et al.* (2011) noted that subsistence farmers in Lesotho have been able to boost agricultural yields and increase food production by adopting conservation agriculture, while Bisangwa (2013) concluded that CA is more effective in terms of soil erosion control, yield stability, reduced machinery use, and lower fuel costs compared with conventional tillage systems. These results compare favourably with similar studies from other countries where CA has shown a positive influence on crop yields, soil fertility, and erosion (Walker *et al.* 2014).

Additionally, CA practices reduce carbon losses that occur with ploughing, and also further sequester carbon via residue incorporation and reduced erosion (Silici *et al.* 2011). Thus, conservation tillage practices have increased smallholder farm systems mitigation against climate change.

The information collected by FAO in 2006 showed that about 850 farmers benefitted from CA (*ibid.*). The World Food Programme has also supported about 5,000 households (1.5 per cent of rural households) in adopting CA in different districts of the country (*ibid.*). The commonly held view in the literature is that CA has resulted in increases in food productivity through higher crop yields, implying food security and, consequently, better economic and social wellbeing. However, there are also strong arguments that its long-term sustainability currently depends on donor support (*ibid.*). In addition, in Lesotho, access to land, especially along gender lines, remains a determinant factor for the adoption of CA among poor households (*ibid.*). According to them, female adopters are the least endowed with assets.

Analysis of reports compiled by the FAO also show that three factors determine the adoption of CA in Lesotho, namely: 1) the economic incentives provided to vulnerable households; 2) the level of education of the head of the household; and 3) the degree of trust and cooperation, especially when combined with a participatory approach pursued by trainers (*ibid.*).

While Lesotho's partners have been actively assisting such households, the sustainability of the programmes remains in doubt, should they pull out. In this regard, there are fears about sustainability of CA outcomes in practice, especially among the most vulnerable households, in the absence of external support. Silici *et al.* (2011) acknowledge this challenge, arguing that food aid and other forms of subsidies should be used carefully so as not to create dependency. Currently, most of Lesotho's development partners highlighted above continue to give out incentives, recognising the positive role they play in motivating poor households during the lean period and in the initial stages of adoption. The customary practice of collecting crop residues and allowing livestock in the harvested fields has also been cited as one of the obstacles to CA adoption (*ibid.*).

5.3.2. Homestead Gardens

The second farming system practiced in Lesotho and deemed climate-smart is homestead or keyhole gardening (Box 4). NGOs are taking a joint and complementary approach in promoting keyhole gardens that grow year-round food and cash crops despite the harsh mountain climate (Billingsley *et al.* 2013).

NGOs such as Send-a-Cow Lesotho (SCL), World Vision Lesotho, International Red Cross Lesotho, and the Catholic Relief Services are engaged in improving household food security through home gardens such as keyhole gardens and trench gardens, which provide vegetables to households and crop residues, to animals (Billingsley *et al.* 2013). Send-a-Cow Lesotho has gained a positive national reputation through its successful promotion of keyhole gardens and double-dug trenches.

Box 4. Keyhole Gardens

The basic keyhole garden is a circular, raised bed made up of layers of soil, ash, manure, and other organic material that retains moisture and nourishes the soil, making it more productive than a conventional garden, even during dry or cold months. The gardens can produce vegetables for a family of five all year round. In Lesotho, the garden is usually walled with local stone or brick that retains day-time heat, alleviating low night-time temperatures. The raised structure also makes access easier for the chronically ill or the elderly. Size can vary, but the basic garden measures 1m high and 2m in diameter.

A keyhole-like 'cut out' or walkway design gives growers 'arms-length access' across the garden. 'Grey' water from household washing is added through a central composting basket, watering the garden and continuously infusing the soil with nutrients. Once built, the garden requires little maintenance and, if cared for appropriately, can produce food for up to five years.

SOURCE: Billingsley *et al.* (2013, 2))

Keyhole gardens have been reported in the literature as having resulted in increased productivity and are much more effective in retaining moisture and increasing yields than traditional gardens.

5.3.3. Block Farming

The Government of Lesotho, through the Ministry of Agriculture and Food Security, is promoting a block farming system. In block farming, farmers cultivate their fields as a group to reduce overall costs and to offer support across the crop-growing spectrum. This is a form of intensified and mechanised farming system aimed at increasing food production both at household and national level. The farming system was introduced by the government in the 2006/2007 cropping season.

Given the importance attached to block farming by the Government of Lesotho, in 2006/2007 the Ministry of Agriculture was allocated M106.1 million (US\$ 9.8m) while in 2007/2008 it got M141.1 million (US\$

13.2m). An extra M59 million (US\$ 5.4m) was allocated to finance agricultural projects, including irrigation crop production to offset the negative impact of the repeatedly increasing drought and supported the block farming with loans of up to M105 million (US\$ 5.5m) (GoL 2008).

However, block farming has not performed according to expectations. The poor performance has been attributed to the non-implementation of some of the farming practices such as liming and ripping as well as the failure by the majority of the farmers to repay their loans. In addition, the scheme has not really benefited the most vulnerable members of the community as, in some instances, ministers who were appointed as mentors for block farming ended up benefitting at the expense of the poor farmers.

5.3.4 Machobane Farming System

The Machobane farming system is one of the farming systems in Lesotho with high adaptability and resilience to climate change (Box 5.3).

Box 5. Machobane Farming System

The Machobane farming system is an intensive cropping system, using crop rotation, relay cropping, and intercropping practices with the application of manure and plant ash (Mekbib *et al.* 2011). The system provides resources to poor farmers with a sustainable system that does not require expensive inputs and is easy to implement. It supplied them with food all year around. To reduce the likelihood of total crop failure and increase productivity, the Machobane farming system takes the following basic technical applications into account:

- the use of organic fertilisers;
- perennial vegetation cover;
- cropping pattern adequate to the varying climate;
- natural pest control; and
- relay harvesting, allowing for almost all year-round harvest.

The philosophy behind the Machobane farming system has to do with self-reliance without external assistance, farmers' appreciation of their own available resources, readiness to work hard, practical learning and teaching on the field, and teaching other neighbouring farmers to spread the technology.

The system promotes organic fertilisers such as animal manure, ashes, and organic waste, mixed in different proportions depending on the crop, to build and maintain soil fertility. It insists on having at least one animal in the household, which provides manure and food (milk, eggs, and meat).

The Machobane system uses crop rotation, inter-cropping (mixing different crops), and relay-cropping (planting the same crop at different times, so it is harvested at different times). It introduces species and varieties, such as winter wheat, peas, and carrots, adapted to different weather conditions.

It was developed in the 1970s, after 13 years of research on the agriculture management techniques that Basotho smallholder farmers were using.

The Machobane farming system has been promoted by NGOs in Lesotho, with a special focus on the RSDA and the Machobane Agricultural Development Foundation (MADF) since the 1950s. The International Fund for Agricultural Development (IFAD) and other NGO's, such as RSDA and MADF have been promoting the system so that other farmers would adopt the farming practices, despite dwindling resources from donors.

Although Lesotho abounds in water resources, there are not many irrigation schemes, and an insignificant percentage of land is under irrigated agriculture. Most of the irrigation schemes, which were built through donor assistance, have not been sustainable, with most collapsing after the pulling out of donors (SADC Report 2010).

There are several small schemes that are still in existence, though. Some of these are managed by private farmers with some assistance from government in terms of irrigation infrastructure and others are run by NGOs.

5.3.1.6. Forestry Programmes: Forest development has been actively promoted in Lesotho for almost 150 years (Esenjor 2004). Attempts to create forest woodlots in rural areas were initiated as far back as 1973 when woodlots were initiated as a solution to chronic fuel wood shortages (Green 1989). The Woodlot Programme project was designed to create forest service, which was to provide the people with fuel wood and poles and at the same time enhance land resources conservation. According to Green (1989), since the inception of the Lesotho Woodlot Project in 1973, awareness of the potential of tree planting in Lesotho has grown among the rural populace. However, the project did not succeed due to inter-village hostilities and squabbles over land, which resulted in the local people destroying the woodlots (Esenjor 2004).

Other afforestation schemes that have been established in Lesotho include the Community Social Forestry (CSF), the Matelile Rural Development Project, the Forestry Component Project, the Maphutseng Farm Improvement with Soil Conservation Project, the Thabana-Morena Development Project, the IFAD Project, and the Food Security Assistance Programme (Esenjor 2004). Some of these schemes have been effective due to the involvement of local people in tree planting and management. However, others have argued that people were negatively disposed of such woodlots under the customary land tenure system.

Agro-forestry-related practices have, however, been largely confined to home gardens where woody perennials are planted in mixtures with crops and vegetables (Green 1989). In the fields, fruit trees are planted along the contour ridges.

5.4. Discussion of Climate-Smart Agriculture Intervention Programmes

The examination of CSA practices in Lesotho shows that a wide range of interventions with the potential to increase food production and the adaptive capacity of the rural livelihoods, as well as reduce GHG emissions are in place. Several cases studied reported experiencing increased food production upon the introduction of CSA-related practices embedded in the policies. Thus, CSA initiatives with long-term benefits to rural livelihoods exist.

However, in contrast to the potentials of CSA raised in this chapter, there is little sign of CSA adoption beyond the plots where donors have provided input support. It would seem that most successful CSA practices documented are limited to externally supported initiatives, raising a question about sustainability of the programmes. Currently, NGOs or/and other donor subsidies on inputs persuade some smallholder farmers to adopt CSA interventions. Thus, despite increased production and possibly reduced erosion from CA use, more information is needed to really assess the net effect of this intervention, should the donor community stop the subsidies. Those promoting CSA interventions should also be aware of the labour and capital limitations smallholder farmers face in CSA adoption and understand that these are likely to vary by household, considering the threats posed by HIV and AIDS to most households.

The policy of subsidising inputs to promote block farming has been highly criticised for being riddled with corruption. Results from previous studies suggest that input subsidies have not benefitted most smallholder farmers as the system was hijacked by politicians and those well connected. The skewed patterns of adoption of the block farming in favour of better-resourced and connected farmers indicate a need for more explicit targeting of resource-poor farmers. These are the households that must be reached if wider adoption and impacts of CSA programmes are to be achieved.

To date, most NAPA priorities largely remain on paper. There are also additional potential explanations for failure to implement NAPA activities, including: inadequate institutional and systemic capacity for climate change initiatives; lack of human resource skills at the community and institutional level to address environmental issues; and a lack of awareness on the impact of climate change on peoples' livelihoods (Hove *et al.* 2011). According to Hove *et al.* (2011), current projects mainly focus on capacity building with few focusing on the implementation of NAPA prioritised adaptation measures. Inputs for CA, such as equipment, recurrent expenses needed to either undertake CA practices or purchase seeds and fertilisers are still largely donor-driven and, therefore, unsustainable in the long run (Silici *et al.* 2011).

Insecure tenure arrangements based on gender still pose a challenge despite several commendable efforts to reform archaic institutions. According to

the country's Constitution, women still have access to land through their husbands and remain legal minors. Such lands are lost if the woman is divorced from her husband.

6. Conclusion and Recommendations

Climate-smart agriculture has become part of the international discourse on sustainable livelihoods because of the realisation that, while agriculture plays an important role in the socio-economic development of many developing countries, it faces several challenges relating to low productivity levels, resulting in widespread food insecurity. These challenges are worsened by climate change, hence the need to adopt climate-smart agriculture that encompasses both adaptation and mitigation.

The starting point for this chapter was the concern over appropriate CSA policy responses to climate-change challenges in Lesotho. There is a strong indication that the Government of Lesotho has enacted sectoral policies in order to achieve the objectives of CSA. Several policies aimed at alleviating poverty, while increasing farmers' resilience and reducing greenhouse gas emissions, have been put in place. However, whilst this is commendable, gaps were identified both within and between the policies which act as a barrier to CSA. It is, therefore, imperative to address such barriers in order to increase the adoption of CSA by smallholder farmers.

The study concluded that smallholder farmer adoption rates of CSA can be improved by developing a national climate-change policy with full legal and budgetary support.

Currently, NGOs have been the major actors in support of CSA projects. The most important gap in the adoption process is the sustainability of such interventions in the event of donor support ceasing. Despite the alternative that CSA offers to many farmers, its widespread adoption has not occurred because of constraints associated with inputs without external support.

The main factors currently constraining the implementation of NAPAs are assets and institutions. A lack of assets, such as finance or equipment, limits CSA adoption. That means more attention needs to be paid and development efforts have to be made to CSA interventions that require few assets. Decision makers also need to recognise that CSA technologies that build on assets are less likely to be adopted without the necessary support, both budgetary and policy wise.

There is clearly a case for improving gender policies to ensure that both men and women are able to access land and other resources that support CSA, especially female-headed households. However, there is a need to amend relevant sections of the Constitution that are still not climate-smart.

This chapter, based on previous success stories in the literature, makes the following recommendations:

- There is a need to tackle climate change within an integrated environmental and development framework. The general consensus in the literature is that a more integrated and holistic national climate change policy would address climate change adaptation and mitigation simultaneously. To this end, there is a need for a clear and stand-alone climate-change policy rather than the current situation where various sectors strewn across different ministries have their own policies, duplicating efforts and overlapping in many areas. A holistic climate-change policy is important for integrated planning, which makes it possible to respond to climatic variability and climate change in an integrated way. Such a policy would help to:
- Ensure credible and legally mandated institutional arrangements that would promote a coordinated approach to climate-smart agriculture. There is a need to ensure that climate-smart agriculture policies at various levels are coordinated. Since climate-smart agriculture depends on other policies, including land policy, it is important that the National Vision 2020 and the National Strategic Development Plan 2012/13–2016/17 are developed and supported by the National Climate Change Policy.
- While it is important for policy makers to take into account traditional land tenure systems regarding ownership, access, and management in order to enhance CSA capabilities, there is a need to reform those aspects that are not climate-smart, such as not being gender neutral. In the case of Lesotho, this requires reforming Section 18 (4) (c) of the Constitution, which gives priority to customary law that regards women as legal minors. While the Government of Lesotho needs to be commended for coming up with the Land Act of 2010, which now gives everyone equal access and ownership to land, there is a need for the relevant sections of the Constitution to be aligned with the new development enshrined on the Land Act of 2010.

Notes

- ¹ The term ‘gender’ is used to refer to the socially-constructed different roles, rights, and responsibilities of men and women and the relations between them. The roles and relations between women and men are dynamic; they do change over time and also depend on age, class, race, ethnicity, social and marital status (Doss 2001).

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CHAPTER THREE

Effects of Climate Change on Agricultural Productivity across East African Countries: Comparative Evidence from Kenya and Uganda

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Abstract

The potential of Africa's agriculture as the backbone of the continent's economies has been heavily impeded by climate change and variation due to gross dependence on weather events in Sub-Saharan Africa. As a response, climate compatible development initiatives have been implemented in some countries in the East African region. Consequent upon this emerging scenario and as a means of assessing climate compatible development initiatives, the study analysed the effects of climate variables on agricultural productivity across East African countries with comparative evidence from Kenya and Uganda. Specifically, it assessed the changes in major climate variables in the region over the study period; determined the growth rate of productivity among the commodities; estimated the influence of climate variables on productivity of the commodities; and deduced policy implications from the findings. The study period was 1970 – 2010 while maize and cassava were selected because of their production ranking in the two countries based on the World Food and Agriculture Organisation statistics. Data analysis was done using trend analysis, log quadratic trend equation and multiple regression model. Results showed that precipitation pattern in Kenya and Uganda traced out high amplitude decadal variability, though more diverse in the former, with the forecast showing off a slightly upward trend. In temperature, the inter-annual variability observed in Kenya was wide with a forecast of a steep rise up to 2010 while Uganda posted a continuous rise all through. The carbon dioxide emission increased in both countries with slight irregularity and showed a huge promise of future upward trend. In terms of productivity, the log quadratic trend equation showed that maize experienced deceleration in Uganda while Kenya recorded acceleration within the period. However, the productivity of cassava in Uganda and Kenya stagnated with varying degrees of compound growth rate among other results.

Keywords: Agriculture, climate change, development, productivity.

1. Introduction

1.1. Background

Agriculture is the backbone of Africa's economies, contributing an estimated 32% to her overall economic activity and employing about 65% of the continent's working population (KPMG 2013). This shows that the sector has the greatest potential to influence the lives of millions of people

in Africa (Asante and Amuakwa-Mensah 2015). This potential has been heavily impeded by climate change and variation due to gross dependence on weather events in sub-Saharan Africa (SSA), where 97% of the agricultural land is rain-fed. Consequently, farmers who constitute the majority of the poor in Africa face prospects of tragic crop failures, reduced agricultural productivity, production uncertainties, and spiral price rise of their commodities. The continent is a region considered a climate change hotspot because it is highly populated with widespread poverty and large areas under low agricultural productivity. Overall agricultural productivity loss in Africa due to climate change is estimated to be between 17% and 28% as compared to 3% to 16% for the world as a whole (Aggarwal, Zougmore and Kinyangi 2013; Rockstrom *et al.* 2004; Cline 2007) by the 2080s.

For most countries in East Africa, small-scale agriculture is the main economic activity and source of livelihood for most people living in rural areas. However, the agricultural sector in these areas is particularly vulnerable to adversities of weather, not only because farmers depend on rain, but also on small pieces of land. These smallholder farmers thus already operate under pressure from food insecurity, increased poverty and water scarcity (CEPPA 2006; Regassa, Givey and Gina 2010).

As climate is a primary determinant of agricultural productivity, any change will influence crop growth and yield, hydrologic balances, supplies of inputs and other components of managing agricultural systems. Yet, the nature of these biophysical effects and the human responses, including adaptation, remain complex and uncertain (Knox *et al.* 2012). For comparison, warming through the 20th century was at the rate of about 0.05°C per decade. Precipitation patterns in East Africa are more variable; however, historical records indicate that there has been an increase in rainfall over the last century. Under the intermediate warming scenarios, parts of equatorial East Africa will likely experience 5 – 20% increased rainfall from December to February and 5 – 10% decreased rainfall from June to August by 2050 (Hulme *et al.* 2001; IPCC 2001).

In Kenya, for example, the declining agricultural productivity is a real challenge for a government with a population of over 40 million to feed (Mohajan 2014, 2). This is worse as global circulation models predicted that global warming will lead to increased temperatures of about 4°C and cause variability of rainfall by up to 20% in Kenya by the year 2030. From these predictions, the two extreme climate events that may adversely impact on the agricultural sector are drought (crop water stress leading to declining yields) and flooding (resulting in water logging) in both the ASALs and high potential areas (Kabubo-Mariara and Karanja 2007). In a related development, the African Centre for Technology Studies (ACTS) concluded that agriculture in Uganda is highly susceptible to changes in climatic conditions and the most important factor limiting productivity is precipitation (Orindi and Eriksen 2005). More so, Uganda continues to be

one of the poorest nations in the world, with 24.5 per cent of the population living on less than \$1.25 a day (ARCC 2013, 14). However, Aizhen *et al.* (2013) observed that there is dearth of studies that examined the relationship between climatic conditions and agricultural productivity in Uganda. Consequent upon this emerging scenario, it is glaring that these phenomenal changes in climate have made it essential to systematically integrate synergies between mitigation and adaptation in the existing food security system and development strategies in the region. Therefore, the need for climate compatible development (CCD) becomes imperative. As a development paradigm, CCD moves beyond the traditional separation of adaptation, mitigation and development strategies to the creation of a new integrated development landscape. This new approach nurtures and sustains economic growth as well as social development in the face of climate threats and uncertainties while cutting emissions or keeping them low (Mitchell and Maxwell 2010). While the CCD concept is beginning to be expressed in climate specific documents of a number of countries in East Africa, their full integration into national plans and budgetary frameworks cum effective coordination mechanisms is crucial. This is because CCD needs to touch on all sectors including agriculture in terms of regulatory and fiscal policy measures to deliver 'triple wins'. According to FAO (2010, ii), the concept of 'triple wins' originated in the form of 'climate-smart agriculture'; agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gases (mitigation), and enhances achievement of national food security and development goals. On the strength of the fact that productivity growth is an integral part of climate compatible development, the study sought to analyse the effect of climate variables on agricultural productivity across East African countries with comparative evidence from Kenya and Uganda. It specifically: (i) assessed the changes in major climate variables in the region over the study period; (ii) determined the growth rate of productivity; (iii) estimated the influence of climate variables on productivity of the commodities and deduced policy implications from the study.

1.2. Statement of the Problem

In the eastern African region, the increase in the gap between population growth and agricultural capacity is exacerbating the already declining food security, and increasing vulnerability and rural poverty, which amplify the impacts of climate change that appear to have become more severe in the recent years (Funke *et al.* 2008; Bagamba *et al.* 2012). Even with the incorporation of climate compatible development tenets in policy engineering efforts of some east African countries, some institutional barriers and lack of synergy among implementing institutions impede attainment of the triple wins strategy (Muok *et al.* 2012). With this growing trend and in the face of poor implementation of agricultural policies and climate compatible development strategies, it becomes an enormous challenge to provide food for the teeming population and raw materials for industries. More so, little or nothing seems to have been done in the context

of assessing regional agricultural productivity and comparing impacts of climate variables on agricultural productivity as a means of driving climate compatible development. Kenya, for example, launched the National Climate Change Response Strategy (NCCRS) in 2009 with reasonable CCD elements/initiatives (such as forest cover restoration project, carbon sequestration through conservation tillage, and limiting the use of fire in a rangeland and cropland management). The extent of influence of the strategy on addressing food security issues including agricultural productivity is, however, unclear. In addition, lack of synergy between the countries of the region in addressing climate-change-related impacts for the purposes of benefiting from mutual regional policy engineering, climate compatible development collaborations, etc. is observed. This study therefore attempts to fill these lacunae in knowledge and as a means of measuring climate compatible development interventions by estimating and comparing the effect of climate variables on agricultural productivity in Kenya and Uganda.

1.3. Methodology

The methodology is drawn from the notion that climate change impacts usually depend on a range of climate parameters' changes and on the country's social, cultural, geographical and economic backgrounds. In this context, the study employed a statistical model that relates productivity to meteorological data in line with prior studies (Torvanger, Twena and Romstad 2004; Ajetombi and Abiodun 2010; Mbanasor *et al.* 2014). This assumed a quadratic relationship between yield per hectare $Y(\text{tons/ha})$ and temperature $T(^{\circ}\text{C})$, precipitation $P(\text{mm})$, carbon dioxide emission $R(\text{kt})$ and a time trend, τ .

$$Y_{jt} = \alpha_0 + \alpha_1 T_{jkt} + \alpha_2 P_{jkt} + \alpha_3 R_{jkt} + \alpha_4 T_{jkt}^2 + \alpha_5 P_{jkt}^2 + \alpha_6 R_{jkt}^2 + \alpha_7 \tau_{jkt} + \omega_{jkt} \dots\dots(1)$$

Where j is the country index, t is the time index, k is the commodity index, ω is the error term, $\alpha_0 - \alpha_7$ are the estimated parameters. The study period was 1970 – 2012 while maize and cassava were selected because of their ranking and listing among top ten commodities in Kenya and Uganda, based on FAO statistics. This model, quadratic function of multiple regression was applied in the bid to estimate the influence of climate variables on productivity of the commodities. Given that the study was longitudinal, the data set for each of the variables were subjected to unit root test to ascertain stationarity before analysis. For assessing the changes in major climate variables, trend analysis was applied while log quadratic trend equation was fitted in determining the growth rate of productivity among the commodities and stated thus:

$$\ln Q_t = a + b_t + c_t^2 + U_t \dots\dots\dots(2)$$

A positive significant value of c indicates acceleration while a negative significant value implies a deceleration. A non-significant value shows

stagnation in the growth process. This is in line with Onyenweaku (1993; 2004).

The study period was 1970 – 2010; thus, the data of interest were secondary and include productivity (yield per unit area), annual precipitation, temperature and carbon dioxide (CO₂) emission over the study period. These were obtained from databases hosted by the Food and Agriculture Organisation of the United Nations (FAOSTAT), the World Bank and United Nations Development Programme (UNDP).

1.4. Organisation of the Chapter

The chapter is organised into four sections presented as follows: the first section is the introduction and presents the background, summarises the problem statement, highlights the methodology and organisation of the chapter. Section two reviews major theories associated with agricultural productivity and outlines constructs/variables related to the discussion. Section three presents results and discussion while section four focuses on the conclusion and policy implications.

2. Theoretical and Conceptual Literature

2.1. Major Theories Underpinning the Study

The primary step in any attempt to evolve a meaningful perspective on the process of agricultural development is to perceive the view of agriculture in pre-modern or traditional societies as essentially static. Viewed in a historical context, the problem of agricultural development is not that of transforming a static agricultural sector into a modern dynamic sector, but of accelerating the rate of growth of agricultural output and productivity consistent with the growth of other sectors of a modernising economy. Modern economy (for example, green economy) will require development resources to be stretched to meet the growing demands under changing climate (Stern 2006; Tompkins *et al.*, 2013). This, therefore, makes the concept of climate compatible development relevant and inevitable.

A number of theories have been advanced to explain the productivity scenario. The diffusion model holds that better husbandry practice was a major source of productivity growth even in pre-modern societies. The diffusion approach to agricultural development rests on the empirical observation of substantial differences in land and labour productivity among farmers and regions. In the view of this theory, the path to agricultural development is through more effective dissemination of technical knowledge and a narrowing of the dispersion of productivity among farmers and among regions. This model has provided the major intellectual foundation for much of the research and extension effort in farm management and production economics since the emergence of agricultural economics, in the last half of the nineteenth century, as a

separate sub-discipline linking the agricultural sciences and economics (Ruttan 1977).

The Boserupian theory averred that the primary stimulus to agricultural development and productivity is population growth. This implies, in other words, that population growth or pressure triggered efforts towards increasing agricultural productivity. Over time, her postulation began to be reframed as a more generalised theory and had continued to mature in relation to population and environmental studies. This theory runs counter to Malthusian theory which holds rather an opposing view (Boserup 1965; Elwell 2013).

In a related development, Amartya Sen has, over the last three decades, developed a distinctive normative approach which perceived development as the expansion of individuals' freedom to achieve the kind of lives they have reason to value. This development perspective is understood in liberationist terms: of removing unfreedoms — 'the domination of circumstances and chance over individuals' — and of respecting and supporting individual agency and societal self-determination to decide on and pursue the flourishing life (Wells 2013). This viewpoint, although rudimentary, envisions the concept of wholesome development.

The study also employed induced innovation hypothesis in examining the interaction between climate and productivity growth. Although the hypothesis was originally based on the experience of agricultural development in the United States and Japan (Hayami and Ruttan 1971), lately, it has been employed to explain the complex process of technological and institutional change which represents a major perspective on international development (Koppel 1995). The fundamental insight of this hypothesis is that investment in innovation of new technology is the function of change (difference) in resource endowment and the price of the resources that enters into the agricultural production function. This has spawned a conceptual infrastructure that addresses the wider issues of how farmers and their supporting institutions determine priorities for agricultural production. In the context of this study, climate change alters these climatic resources by changing the growing season, length and soil moisture regimes and by adding heat stress to the crop. Such changes, following the hypothesis of induced innovation, will provide appropriate signals to farmers to induce appropriate response. Translating this argument, the induced innovation hypothesis suggests an important route for the interactive relationship between climate and productivity growth. One of the assumptions made by this hypothesis is that when agents of production (for example, farmers) experience problems with change in resource endowments as a result of climate change, they are likely to seek new knowledge that will help overcome these constraints (Tripathi and Kumar 2014). The gaps created by these constraints are meant to be filled by the implementation of climate compatible development strategies, to avoid solving a problem and creating another.

2.2. Conceptual Framework

Greenhouse gases emissions from human activities are responsible for climate change (IPCC 2007; Li *et al.* 2011). Moreover, climate change triggers increased temperatures, changing rainfall patterns and amounts, and a higher frequency and intensity of extreme climate events such as floods, cyclone, droughts and heat wave (IPCC 2007; Tirado *et al.* 2010; Roudier *et al.* 2011). However, temperature increases and erratic rainfall patterns affect crop agriculture mostly directly cum adversely (Lansigan, De los Santos and Coladilla 2000; Rosenzweig and Tubiell 2007; Almaraz *et al.* 2008), and by extension, food security. Furthermore, the integration of climate compatible development strategies enhances the attainment of food security. The channels of the impacts are presented in Fig.1. Changes in climate generally involve changes in two major climate variables: temperature and precipitation. The increase in temperature shortens the phenological phases of crops (such as planting, flowering and harvesting) (Li *et al.* 2011; Roudier *et al.* 2011; Teixeira *et al.* 2011) and affects plant growth and development). Overall, temperature and rainfall changes reduce the cropped area, production level and yield.

More so, different methods and approaches for estimating the impact of climate change on the agricultural sector are evident in literature. They are grouped into two broad categories: partial economic models and economy-wide models. Partial equilibrium models analyse a single market or commodity or subsets of markets or sectors whilst general equilibrium models observe the economy as a complete system of co-dependent elements, such as industries, factors of production, institutions and the rest of the world (Sadoulet and De Janvry 1995). Partial equilibrium models encompass four approaches: crop modelling/agro-economic, Richardian/cross-sectional, panel data (Deressa and Hassan 2009) and agro-ecological zone (AEZ) (Sarker 2012).

In this study, the crop modelling or production function approach was employed. Based on the climate-yield relationship, the crop modelling approach estimates the effects of climate change on agricultural production (Easterling *et al.* 1993; Adams *et al.* 1998). This model is suitable for the study due to its capability in reflecting the climate-yield relationship. The yield per unit of land function reflects choices of farmers to economic conditions, given climatic parameters. While climate has many dimensions, it was assumed in this study to be represented by average temperature, precipitation and carbon dioxide. This is based on the assumption that there is a monotonic relationship between location and climate. Each crop is assumed to have a range of climate condition where it survives. While holding other variables constant, the yield of each crop reaches a maximum within its climate range and decrease with departures from this until it reaches zero. The conceptual model (Fig. 1), therefore, depicts the linkage between climatic variables and agricultural productivity within the context of climate compatible development.

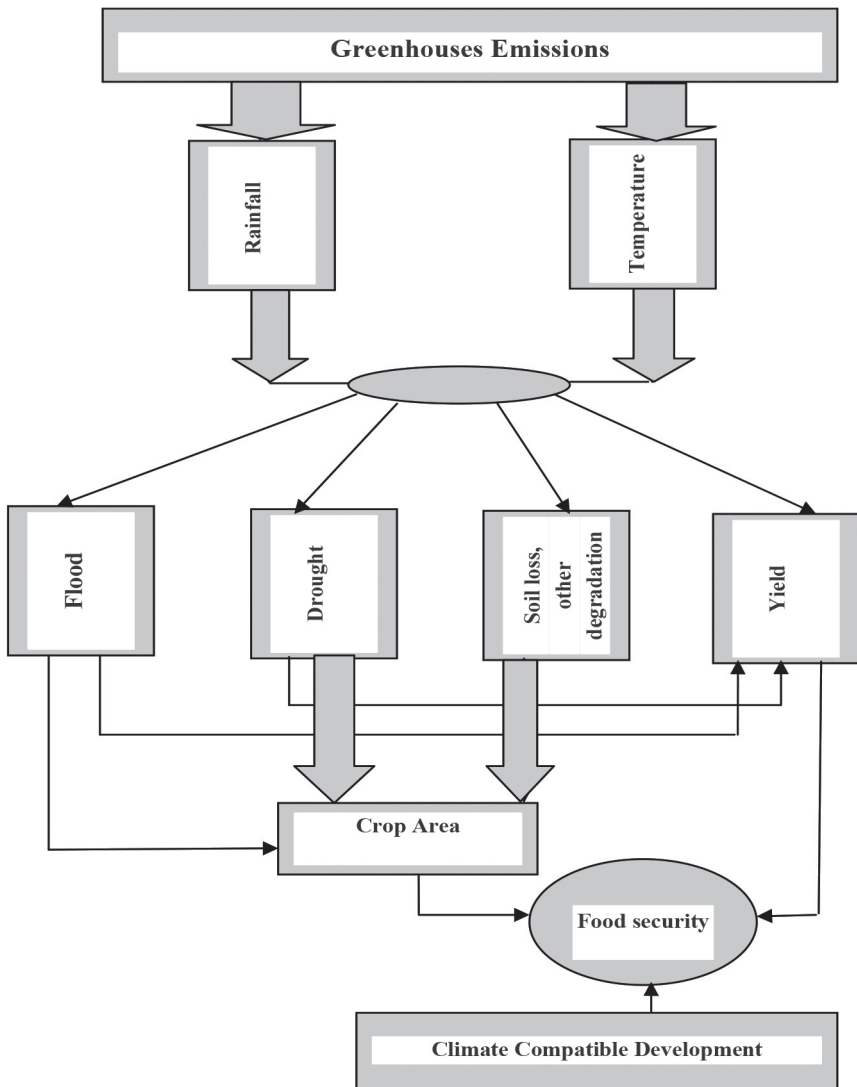


Fig. 1. Conceptual Framework of Climate Change on Crop Productivity

SOURCE: Adapted and modified from Sarker (2012)

2.3. Brief Review of the Empirical Literature

A study conducted by Kabubo-Mariara and Karanja (2007) which focused on the economic impact of climate change on Kenyan crop using Richardian approach, observed that climate affects crop productivity and that Kenya's annual rainfall traced out a strong seasonal pattern. They also realised that there is a non-linear relationship between temperature and revenue on one hand and between precipitation and revenue on the other.

In a related development, Government of Kenya (2005) reported a decline in per capita agricultural production with total annual farm production of food crops lagging behind consumption. The report also observed the resultant effect of the trend on food deficits and insecurity. However, Mulu-Mutuku *et al.* (2013) blamed the problem of dwindling production on the fact that most of the crops are grown by older farmers who have been known to concentrate on major crops (maize, wheat, rice, beans and Irish) with less attention on cassava. On the part of government as reported by Government of Kenya (2013), the problem was a result of annual rainfall which had either shown neutral or slightly decreasing trends due to a general decline in the long raining season.

In the study of the response of maize production in Kenya to price and non-price incentives, Onono, Wawire and Ombuki (2013) realised that maize production responds positively to its output price, development expenditures in agriculture, maize sales to marketing boards, growth in per capita GDP, liberalisation and governance reforms and negatively to poor weather conditions.

In terms of emissions of carbon-dioxide (CO₂), the World Bank (2010) reported that Kenya's CO₂ emissions are 0.3 tonnes per capita; with this, Kenya ranks the second largest emitter with Sudan in east Africa after Djibouti (0.6).

In Uganda, Majaliwa *et al.* (2012) conducted a study on regional climate model and prediction of seasonal rainfall and surface temperature. Their results showed that the models captured fairly well the large-scale flow signals, influencing rainfall and temperature patterns and predicted a decreasing trend of rainfall and temperature in Uganda, especially in the dry seasons.

In Maize production, Okoboi, Kutessa and Barungi (2013), based on FAO statistics, observed that Uganda's maize output has more than doubled from 0.6 to 1.26 million tonnes over two decades (1990 – 2007). They also realised that yield has declined from about 1.8 tonnes per hectare (t ha⁻¹) in 2004 to 1.5 t ha⁻¹ now, which levelled off to the yield in 1990. However, Kibaara *et al.* (2008) reported consistent growth in maize productivity across most agro-regional zones and panel years. Similarly, in a study conducted in Ghana by De-Graft Acquah and Kyei (2012), yield variability of maize was observed to be negatively related to rainfall and temperature. Other previous studies which realised that variability in temperature

resulted in changes in agricultural output include Hepworth and Goulden (2008); Singh *et al.* (2007); Nelson *et al.* (2009); Mwaura and Okoboi (2014).

3. Results and Discussion

3.1. Changes in Precipitation, Temperature and Carbon dioxide Emission (1970–2010)

3.1.1 Precipitation

Figure 2 shows the mean annual precipitation pattern for Kenya for 41 years between 1970 and 2010. The trend has been unstable with precipitation level at the highest in 1997 and the lowest in 2000. The inter-annual sequence turned out a high amplitude decadal variability with visible absence of order. By implication, the estimated variability indicated that the amount of rainfall and the corresponding number of wet days varied appreciably from year to year. This is in line with the finding of Kabubo-Mariara and Karanja (2007) who observed that Kenya's annual rainfall genuinely follows a strong seasonal pattern. The trend forecast indicated that the precipitation in Kenya will experience very marginal increase in the next ten years. The mean absolute per cent error (MAPE) (5.3605) produces a measure of relative overall fit and assesses the rate of accuracy of the fitted time series. In consolidation, the Government of Kenya (2013) reported that annual rainfall shows either neutral or slightly decreasing trends due to a general decline in the length of the raining season.

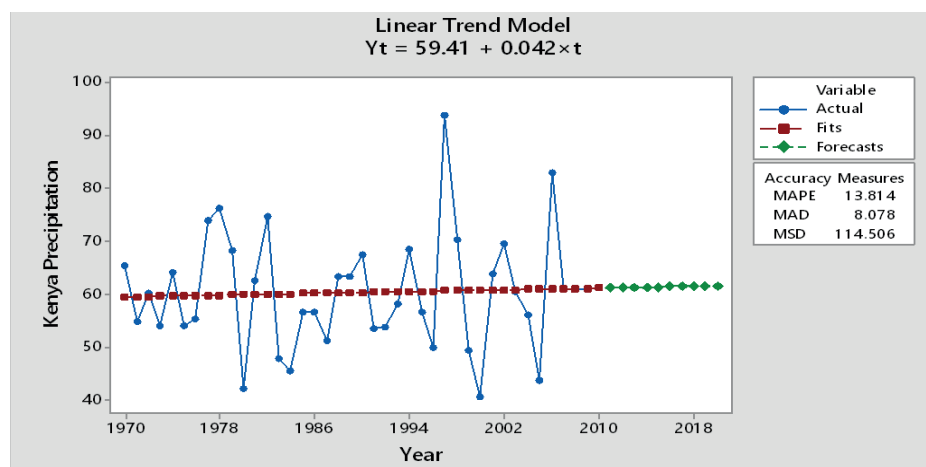


Figure 2. Mean Precipitation (mm) Trend for Kenya, 1970–2018

SOURCE: Authors analysis from study data

Similar to Kenya, the pattern of mean annual precipitation in Uganda between 1970 and 2010 has been unstable; the highest precipitation level was recorded in 1988 while the lowest was in 2000 (Fig. 3). The annual variability became quite high after 1977 and the sequence traced out a very inconsistent and poor distribution pattern. However, both countries had the widest inter-annual precipitation gap within the same period, 1994 and 2002. Unlike Kenya's precipitation pattern, the trend forecast of Uganda showed a slight decrease in the next ten years. This is consistent with Majaliwa *et al.* (2012) who predicted a decreasing trend of rainfall in Uganda. The increase of accuracy by MAPE (Mean Absolute Percentage Error), MAD (Mean Absolute Deviation), and MSD (Mean squared deviation) are relatively similar with the estimates of Kenya. They confirm reasonable rate of accuracy of the fitted time series.

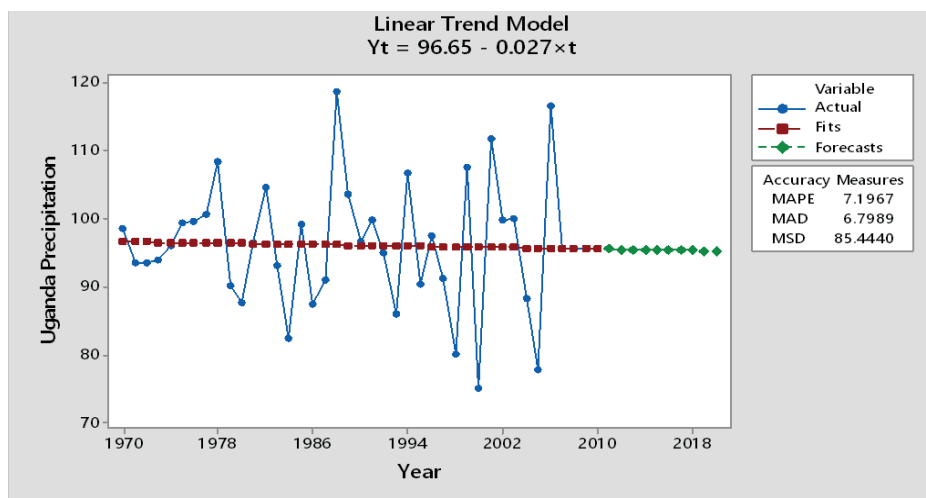


Figure 3. Mean Precipitation (mm) Trend for Uganda, 1970–2018

SOURCE: Authors analysis from study data

3.1.2. Temperature

The mean annual temperature of Kenya showed an unsteady rise over the period (Figure 4). The inter-annual gaps are relatively wide and also traced at a general increase in temperature. The lowest temperature was observed in 2006 and the highest in 2010. Since 2006, the annual temperature seemed to have been on the increase. The forecast trend also indicates a steep rise up to 2020.

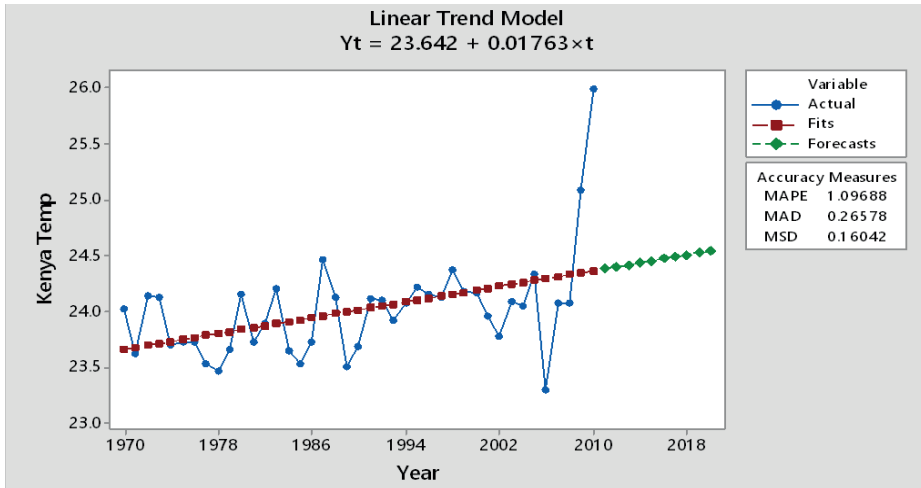


Figure 4. Mean Temperature (°C) Trend for Kenya, 1970–2018

SOURCE: Authors analysis from study data

Mean temperature for Uganda showed a continuously rising trend over the period (Figure 5). Although the inter-annual variability seemed to show a similar pattern, the rise is steeper than that for Kenya. The lowest temperature was observed in 1977 while the highest was in 2008. The mean temperature is traced at a continuously increasing trend.

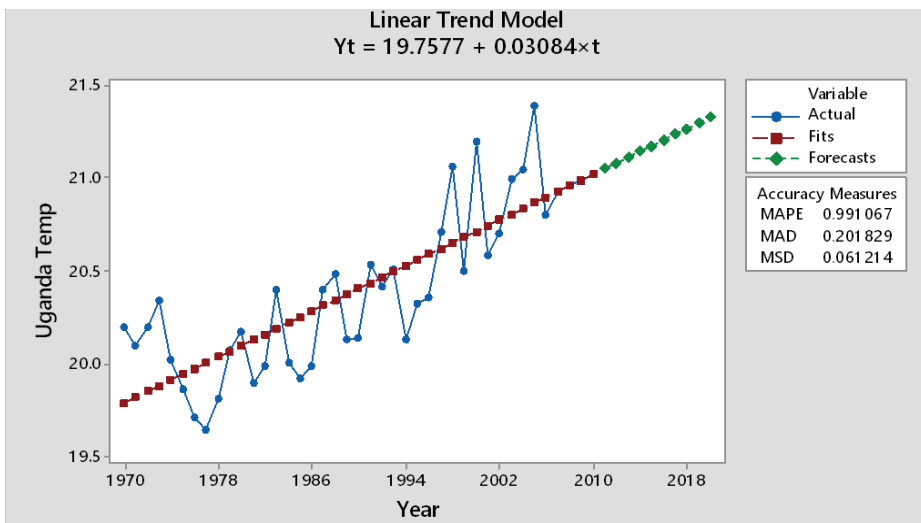


Figure 5. Mean Temperature (°C) Trend for Uganda, 1970 – 2018

3.1.3. Carbon Dioxide Emission

As shown in Figure 6, the carbon dioxide (CO₂) emission in Kenya was relatively high in the 1970's but lowered in the 1980's and 1990's, after which it had been on the increase and reached the highest point in 2010. Thus, CO₂ emission in Kenya had an unstable trend. The ten-year trend forecasts (2011–2020) arrived at by the authors' calculation using a software called Minitab suggest that the CO₂ emission will continue to increase. According to the World Bank (2010), Kenya's CO₂ emissions are 0.3 tonnes per capita; and that put the country as the second largest emitter in the east African region with Sudan after Djibouti (0.6). Although the emissions are low in Kenya at present, the predicted increasing trend is a huge source of concern.

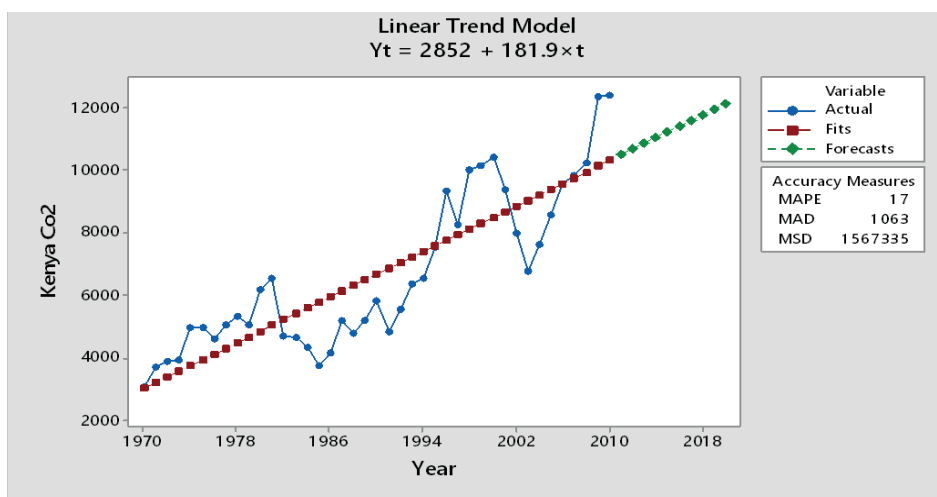


Figure 6. Carbon Dioxide Emission (kt) Trend for Kenya, 1970–2018

SOURCE: Authors analysis from study data

The CO₂ emissions trend for Uganda had been contrary to the pattern for Kenya (Figure 7). For most of the period under review, CO₂ emission level was low with the least level recorded in 1994. However, an increasing trend was traced out from emission level of 1994.

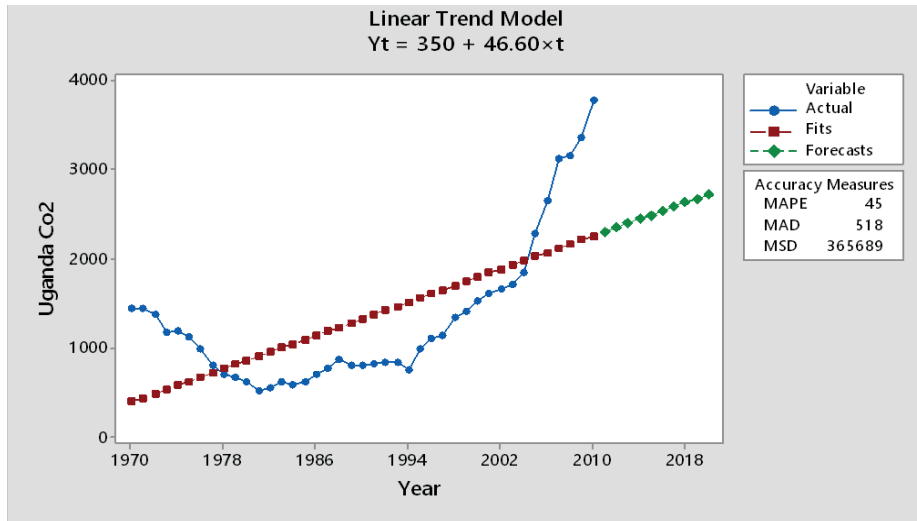


Figure 7. Carbon Dioxide Emission (kt) Trend for Uganda, 1970–2018.

SOURCE: Authors analysis from study data

3.2. Summary of Crop Yield Data

During the study period (1970–2010), the productivity of cassava in Kenya and Uganda had a mean of 9.8225 and 9.7514 tons/ha, respectively (Table 1). The corresponding standard deviations were 2.07897 and 3.52839 tons/ha. The gap between the minimum and maximum values of productivity in both countries was not large, which implied that productivity increase during the period was not tremendous.

The productivity of maize in Kenya recorded a mean of 1.7639 ton/ha while Uganda posted 1.6417 tons/ha. The productivity difference between the minimum and maximum values as was 0.96 tons/ha and 1.89 tons/ha for Kenya and Uganda, respectively. Although the differences were marginal, the standard deviations of 0.26392 tons/ha and 0.39469 tons/ha for Kenya and Uganda, respectively, indicate minimal variability.

Table 1. Summary statistics of crop yield

Variable	Mean	Minimum	Maximum	Standard deviation
<i>Cassava Productivity</i>				
Kenya	9.82	5.51	15.14	2.079
Uganda	9.75	4.23	15.88	3.528
<i>Maize Productivity</i>				
Kenya	1.76	1.32	2.28	0.264
Uganda	1.64	1.07	2.96	0.95

SOURCE: Authors' calculation from study data

3.3. Determination of Productivity Growth

To determine the productivity growth of cassava and maize in Kenya and Uganda, a long-quadratic trend equation was fitted to the data with the intent to establish whether the commodity experienced stagnation, acceleration or deceleration within the study period.

The results of growth rates analysis revealed that Kenyan cassava recorded negative and non-significant productivity during the study period (Table 2). A compound growth rate of 1.715% implies that the supply capacity of Kenya to national and regional cassava markets is insignificant and thus, productivity stagnated. According to Government of Kenya (2005), Kenya has been experiencing decline in per capita agricultural production with total annual on-farm production of food crops lagging behind consumption. This has resulted in food deficits and the consequential food insecurity being witnessed in the country. Over time, agricultural commodities in Kenya concentrated on improvement of production of major food crops such as maize, wheat, rice, beans and Irish potatoes and as such, cassava enjoyed little or no attention. They tended to be grown by older farmers (Mulu-Mutuku *et al.* 2013).

Given that the decision rule stipulates that a non-significant value of cassava shows stagnation, it could be inferred that the productivity of cassava in Kenya experienced stagnation during the study period.

In Uganda, cassava productivity posted a compound growth rate of 2.943% with a non-significant negative coefficient for the time term. This shows that there had been stagnation in the productivity growth of cassava during the study period. This result generally is an indication of continued neglect of agricultural development in terms of allocation of production inputs to the crop subsector (Idachaba 2006).

Table 2. Estimated Productivity Growth of Cassava and Maize in Kenya and Uganda

Variable/cro	a_t	b_t	C_t^2	R^2	F	R
Kenya	8.903	0.017	-3.15E-4	0.57	2.561	1.71
Cassava	(83.343)**	(1.433)	(-1.166)	1		5
	*					
Uganda	8.440	0.029	-5.78E-5	0.70	44.83	2.94
Cassava	(80.020)**	(2.521)*	(-0.216)	2	0	3
Kenya	7.085	0.031	-6.22E-4	0.39	12.56	3.14
Maize	(119.544)*	(4.705)**	(4.141)**	8	3	5
Uganda	7.213	-0.014	0.001	0.59	27.54	-
Maize	(103.294)***	(-1.827)*	(3.528)**	2	0	1.390

Notes: t- test values in parentheses; *** $\rho < 0.01$, ** $\rho < 0.05$, * $\rho < 0.1$

In terms of maize productivity growth, Kenya recorded a compound growth rate of 3.145% with a significant negative coefficient for the time term. By implication, the productivity of maize in the country experienced deceleration within the study period despite 3.145% growth per cultivated area. This is consistent with the findings of Onono *et al.* (2013) who found that the production trend of maize in Kenya showed deficits in most years; the deficits were attributable to poor weather in some of the years among others.

In Uganda, maize productivity experienced a compound growth rate of -1.390% with a significant positive coefficient for the time term. This implies that in the long run, the productivity of maize suffered deficits while yield per unit of cultivated area grew over the period. With the significant positive coefficient for the time term, the productivity of maize in Uganda experienced acceleration. Although Okoboi, Kutessa and Barungi (2013), based on FAO statistics, observed that Uganda's maize output has more than doubled from 0.6 to 1.26 million tonnes over two decades (1990 – 2007). They also realised that yield has declined from about 1.8 tonnes per hectare ($t\ ha^{-1}$) in 2004 to $1.5\ t\ ha^{-1}$ now, levelling off to the yield in 1990. The changes in output between 2005 and 2010 may probably be responsible for the plausibility of our result.

3.4. Influence of Climate Variables on Maize and Cassava Productivity

Prior to the estimation of the influence of climate variables on maize and cassava productivity in Kenya and Uganda, the test variables (precipitation, temperature, CO_2 emission and yield per unit of cultivated area) were subjected to unit root test using Augmented Dickey-Fuller test (ADF). This is to ascertain the order of integration of the variables. The unit root test attempts to determine whether or not a given time series data is consistent

with a unit root process. The presence of unit root could lead to false inferences in regression with time series (Gujarati 2004).

From the results of the ADF unit root test presented in Table 3, all the variables were not stationary at levels. The coefficients compared with the critical values revealed that all the variables were not stationary at levels became stationary at first difference except carbon dioxide emission which attained stationarity at second difference. On the basis of the above, the null hypothesis of non-stationary was rejected and the data set was safe to conclude that the variables are stationary.

Table 3. Augmented Dickey-Filler (ADF) test for integration order

Variable	ADF		
	1(0)	1(1)	1(2)
Cassava productivity _K	-4.445	-	-
Cassava productivity _U	-0.320	3.816	-
Mean Annual Precipitation _K	-5.423	-	-
Mean Annual Precipitation _U	-5.321	-	-
Mean Annual Temperature _K	-1.142	-6.156	-
Mean Annual Temperature _U	-2.616	-7.297	-
CO2 Emission _K	-2.063	-4.445	-
CO2 Emission _U	-1.728	-0.021	-6.854

Note: ***, ** and * indicate that the ADF test statistics are significant at 1%, 5% and 10%, respectively while -3.6067, -2.9378 and -2.6069 are Mackinnon critical value for rejection of hypothesis of unit root at 1%, 5% and 10%, respectively. K represents Kenya and U denotes Uganda.

The regression analysis on the influence of climate variables on cassava productivity in Kenya and Uganda is presented in Table 4. The R squared (coefficient of multiple determination) values of 0.511 and 0.813 for Kenya and Uganda, respectively show reasonable goodness-of-fit for the data sets. By implication, the total variations in cassava productivity were accounted for by the regressors included in the model to the tune of 51% and 81% in Kenya and Uganda, respectively. The F-ratios for the two countries are statistically significant, and the result confirms the overall explanatory power of the model. With these diagnostic statistics, the result of the analysis is therefore reliable and can be used for drawing inferences.

Carbon dioxide emission had a negative coefficient and statistically significant at one per cent level of probability. This implies that increase in carbon dioxide emission could lead to increase in cassava productivity in Kenya in the short run. This is plausible given that crops require carbon dioxide for the production of food through the process of photosynthesis. The coefficient of temperature squared posted a negative sign and was significant at 5% risk level. By this result, it is anticipated that reduction in temperature in the long run could result in productivity growth. This is consistent with the findings of previous studies (Hepworth and Goulden

2008; Singh *et al.* 2007; Nelson *et al.* 2009; Mwaura and Okoboi 2014) that changes in temperature result in changes in agricultural outputs. Prevailing temperature has a number of implications to crop physiology and its immediate environment. It also impacts on a number of physiological processes that lead to the varying levels of productivity among crops.

Time variable recorded a positive coefficient and sparingly significant (10% probability level), indicating that cassava productivity could rise with time. However, we maintained a high standard by accepting only variables that are significant at 5% level of probability.

Table 4. OLS estimates of the influence of climate variables on cassava productivity

Variable	Coefficient	
	Kenya	Uganda
Constant	22.097** (3.825)	-118.050 (-0.452)
Precipitation	-0.003 (-0.234)	-3.5E-5 (-0.881)
Temperature	-1.035 (-1.277)	0.012*** (9.999)
CO ₂ emissions	0.010*** (4.043)	-1.127** (-3.446)
Precipitation squared	-4.5E-5 (-0.182)	0.026 (1.182)
Temperature squared	-0.574** (-3.501)	0.049 (0.297)
CO ₂ squared	8.5E-9 (0.026)	0.001 (1.633)
Time	0.053* (1.865)	1.523 (0.159)
R ²	0.511	0.813
F-ratio	2.127*	20.530***

t- test values in parentheses.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

In Uganda, cassava productivity was determined by temperature and CO₂ emissions which recorded positive and negative coefficients, respectively. It could be inferred that increasing temperature and low CO₂ emission enhance cassava productivity in Uganda.

The ordinary least square estimates of the influence of climate variables on maize productivity are presented in Table 5. Among the test variables for

Kenya, the CO₂ squared term and time variable were significant at 5% probability level with varying signs. While CO₂ squared term possessed a negative coefficient implying that declining CO₂ emissions could lead to enhanced productivity, the positive sign borne by the time variable indicates that maize productivity increases with time. However, in Uganda, only the squared terms of precipitation and temperature were significant at 5% probability and possess negative coefficients. This implies that reduction in precipitation and temperature would lead to increased productivity of maize in the long run. The results corroborate the findings of De-Graft Acquah and Kyei (2012) who obtained that yield variability of maize in Ghana is negatively related to rainfall and temperature.

Table 5. OLS estimates of the influence of climate variables on maize productivity

Variable	Coefficient	
	Kenya	Uganda
Constant	1.432 (1.313)	1.8E6* (2.408)
Precipitation	-8.7E-4 (-0.403)	-0.015 (-0.129)
Temperature	-0.057 (-0.376)	-0.658 (-0.188)
CO ₂ emissions	1.4E-4* (2.010)	-33.002 (-0.018)
Precipitation squared	-4.1E-6 (-0.089)	-180.026** (-2.771)
Temperature squared	-0.001 (-0.028)	-817.137** (-2.908)
CO ₂ squared	-1.7E-7** (-2.767)	0.179 (0.083)
Time	0.016** (3.0097)	-3747.302 (-0.134)
R ²	0.468	0.508
F-ratio	2.741*	1.957*

Note: 1. Figures in parentheses are t-test values.

2. ***, ** and * represent significance at 1%, 5% and 10% probability levels respectively.

4. Conclusion and Policy Implications

The study analysed effect of climate change on cassava and maize productivity in East Africa with comparative evidences from Kenya and Uganda and specific interest in a number of important issues. This study is

invariably perceived a veritable means of assessing climate compatible development initiatives implemented in these countries over the years. Topical among the interest were to assess the changes in major climate variables; determine the productivity growth of the commodities and estimate the influence of the climate variables on the productivity of the crops. By applying a number of analytical tools in the bid to realise the objectives, the findings have huge implications both for the countries in particular and the region in general. The poor and uneven distribution of precipitation in Kenya had already taken a heavy toll on the capacity of the country to feed her ever teeming population. With the prediction of marginal increase in precipitation, the performance of maize in the coming years may be adversely affected in Kenya. The effect may likely trigger reduced productivity of the crop and/or increase in the price while consumers may be faced with the option of resorting to substitutes. Similar irregularity of precipitation was observed in Uganda but with an anticipatory slight decrease in the forecast trend. This situation is expected to initiate production uncertainty. However, cassava which is drought resistant may not be adversely affected.

Temperature was observed to have been on the increase with some degree of variability in both countries. This is an indication that both countries have been getting warmer. In the event of continued scenario of this, the use of alternative coping strategies such as irrigation should be explored. CO₂ emissions in both Kenya and Uganda have traced out an increasing trend. The adoption of agro-forestry technologies should be encouraged to ensure that the aggregate emission is kept in balance with nature. However, proper implementation of Kenya's National Climate Change Response Strategy, which drew inspiration from the concept of climate compatible development will reduce climate change impacts.

The productivity of cassava in both countries was observed to have stagnated over the period. In order to meet the rising need for food, the farmers are expected to adopt productivity-enhancing technologies, such as use of improved varieties which are not only high yielding but also resistant to adverse climatic conditions. This is also anticipated to occur in Kenya for maize where productivity decelerated. To properly tackle the menace of climate change, efficient and proactive climate risk management portfolios should be developed at both national and regional levels to deal with the emerging climate exigencies and impacts. Government intervention is also necessary in the area of intensive advocacy and enlightenment campaign among producing communities while monitoring of the implementation of their national response strategies. This is a veritable means of driving the region towards achieving a low-carbon, climate-resilient economy.

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CHAPTER FOUR

Adoption of Green Technologies in the Public Transport Sector: The Case of *Rea Vaya* BRT System, South Africa

Muchaiteyi Togo

Abstract

The transport sector is very important in the South African economy, both in terms of mobility and contribution to GNP. However, the country faces labour mobility challenges in most urban centres due to its apartheid history, which resulted in the residence of low income black labourers in dormitory towns far away from main areas of economic activity. Improvements in public transport are still necessary and, with transport being one of the biggest emitters of carbon emissions in the country, the introduction of Bus Rapid Transit systems enhances mobility while at the same time reducing emissions from transport in the country. Among the studies undertaken to research Bus Rapid Transit systems, none so far exclusively focussed on the relative advantages of implemented green technologies. The aim of this chapter is to identify, explain, and develop a better understanding of green initiatives/technologies and the advantages that they bring about. The chapter focuses on the Bus Rapid Transit system, *Rea Vaya* (meaning “*we are going*”), in the city of Johannesburg. This chapter is based on a qualitative research design and is informed by Everett Rogers’ ‘diffusion of innovations’ theory. Data collection was mainly through literature review and content analysis of archival online news features from the *Rea Vaya* website. The data analysis drew on innovation theory, specifically the concept of ‘relative advantage’. Relative advantage is discussed based on a holistic approach where the three dimensions of the concept of sustainable development — environmental/ecological, social, and economic factors —are considered. The results of the research show that though the project is still under implementation, it has brought about many socio-economic and environmental benefits, ranging from improving accessibility, saving time, and creating jobs to reducing greenhouse emissions. The chapter recommends concerted efforts in behaviour change among motorists to influence modal shifts from cars to *Rea Vaya* BRT systems. It also recommends further research to quantify such benefits.

Keywords: Bus rapid transit, emissions, green technology, public transport, *Rea Vaya*

1. Introduction

Transport contributes to greenhouse gas emissions through combustion of fossil fuels as well as the value chain, including the production of the fuel.

At a global level, transport contributes about 13% of greenhouse gas (GHG) emissions, and projections were that overall transport-related emissions would grow by 57% between 2005 and 2013, with 80% of the projected increase expected to be from developing countries (Global Environment Facility, Department of Transport Republic of South Africa and United Nations Development Programme 2011). This is because developing economies are still growing and the transport sector expands as economies grow, which leads to an increase in emissions from the sector. In Africa, where the bulk of the developing countries are situated, despite historically low GHG emissions compared to other continents, the rapid growth in emissions is due to increase in the use of fossil fuels (Haq and Schwela 2013). This is exacerbated by reliance on imported vehicles which are rather inefficient and poorly maintained, thus increasing GHG and other emissions (*ibid.*). Transport is, therefore, an important sector that has to be considered in terms of mitigating GHG emissions.

Because emissions are still growing within the transport sector, transport is one of the key sectors that the Kyoto Protocol paid special attention to by urging Annex 1 countries "... to reduce and/or limit greenhouse gases ... in the transport sector" (United Nations 1998, 2). Transport is also an issue that was discussed by the United Nations Environment Programme (UNEP) in the Green Economy Report (2011) as a sector in which the green economy can be implemented. UNEP (2011) discusses measures such as "improving energy efficiency across all transport modes and shifting from private transport to public or non-motorised transport" (UNEP 2011, 12). It mentions the provisioning of public transport as a starting point in greening cities (*ibid.*). This is understandably so, bearing in mind that most transport emissions are from the road sector, and globally, the bulk of the emissions are from light vehicles (International Transport Forum 2010).

South Africa has high carbon emissions and the emission levels are characteristic of, and comparable to, developed countries (Togo 2014). The Department of Environmental Affairs (DEA) (2011, 26) argues that if emissions in the country are not controlled, they will continue to grow rapidly and can be "as much as four-fold by 2050". Given the vulnerability of the country to climate change (see Togo, Zhou and Khan 2015) and the potential climate change has in affecting the national socio-economic sector (DEA 2011), it is imperative that the country be involved in greening its economy as part of climate change mitigation strategies.

This chapter is located within the framework of climate compatible development. According to Mitchell and Maxwell (2010, 1), climate compatible development is "... development that minimises the harm caused by climate impacts, while maximising the many human development opportunities presented by a low emissions, more resilient, future". Mitchell and Maxwell (2010) discuss a model of climate compatible development that is inclusive of mitigation strategies, adaptation strategies, and low carbon development, among other strategies.

They also mention the development of low carbon technologies as part of mitigation strategies and identify transport as one of the sectors in which mitigation strategies can be implemented. In South Africa, most emissions are from energy generation (both electricity and liquid fuels) and energy use, including use in the transport sector (DEA 2011). This shows that the transport sector is one of the sectors in which mitigation strategies have the potential to contribute substantially to a reduction in overall national GHG emissions.

Transport is crucial to the South African economy and this is partly because city structures still reflect apartheid planning where black residential areas were located in dormitory townships far away from the main centres of economic activity, which means that poor communities are located far from their areas of work (DEA 2011). These communities constituted about two thirds of the city's population and these were the people who received very low salaries and could not, therefore, afford to buy cars (Goondiwala 2014). This situation was further compromised by under investment in transport (City of Johannesburg Transport Department, n.d.). Many, if not most, of the residents of these townships are employed elsewhere as there isn't much economic activity in the townships, and they have to commute on a daily basis to and from the city and other areas where they would be employed. Currently the transport market is dominated by privately-owned taxis. The country has not been very successful in formalising the taxi industry as part of the public transport market (Venter 2013). Informal taxi operations have many negative impacts which include low vehicle convenience, poor road safety standards and high accident rates, and significant contributions to congestion and environmental impacts (*ibid.*). This chapter focuses on the public transport sector due partly to the socio-economic conditions described above, which make public transport crucial in the country's economy.

Systems like *Rea Vaya*, which use buses, have high potential of reducing emissions if there is a modal shift from cars and taxis to buses. According to Chapman (2007), a double-decker bus can replace about 50 vehicles, making it a more sustainable mode compared to other modes. In addition, the carbon emissions per passenger kilometre are also very low when a bus transports more than 3 people compared to having the people drive their own cars (Stanley and Watkiss 2003, as cited by Chapman 2007, 363). The bus is actually considered the most viable form of urban transport (Bentley 1998, as cited by Chapman 2007). There is, therefore, high potential for climate change mitigation where BRT systems replace smaller vehicles in urban mobility.

In support of climate change mitigation efforts under United Nations Framework Convention on Climate Change (UNFCCC), South Africa made a pledge to reduce emissions below the business-as-usual scenario and to undertake measures that will lead to a reduction in emissions by 34% by 2020 and 42% by 2025 (DEA 2011). GHG emissions are expected to

peak from 2020 to 2025 and then stabilise for about a decade before they start to decline (*ibid.*). The South African government, through various ministries, has committed to greening the economy in various economic sectors of the economy through the Green Economy Accord (Economic Development Department 2011). Commitments that affect the transport sector are as follows:

- *Commitment Six – Biofuels*: The government committed to producing biofuels for mandatory blending of fuel and petrol nationwide so as to contribute to job creation, fuel supply security, and to lowering carbon emissions, and
- *Commitment Nine - Reducing Carbon Emission on Our Roads*: The aim in this case is to promote the use of public transport in such a way that it reduces carbon emissions on the roads, with the initial steps being the implementation of the Rapid Transit System and the Commuter Rail System (Economic Development Department 2011).

Other areas of intervention mentioned in the Green Economy Accord are electric-powered vehicles, which supply biogas to retrofitted public transport vehicles, and solar-powered street and traffic lights (Economic Development Department 2011).

The implementation of the Green Economy is backed by the National Climate Change Response White Paper, the development and implementation of which is overseen by parliament through portfolio committees, which include a committee on transport (DEA 2011). The Climate Change Response White Paper identifies transport to be among the key economic sectors where mitigation potential is high. In tandem with the Green Economy Accord, the White Paper specifies the mitigation options in the sector as energy efficiency applications, “modal shifts (road to rail, private to public transport) and switches to alternative vehicles (e.g. electric and hybrid vehicles) and lower-carbon fuels” (DEA 2011, 27).

The White Paper details the specifics of the transport flagship programme, which is a programme of the Department of Transport, as follows:

The Department of Transport will facilitate the development of an enhanced public transport programme to promote lower-carbon mobility in five metros and in ten smaller cities and create an Efficient Vehicles Programme with interventions that result in measurable improvements in the average efficiency of the South African vehicle fleet by 2020 (DEA 2011, 32).

Key to the transport flagship programme is the BRT system, which is being implemented to promote low-carbon mobility in five metros (Johannesburg included) and 10 smaller cities (Manyungwana 2014).

The development of the BRT in South Africa is governed by the Public Transport Strategy (2007–2010), which was released in 2006 and approved in 2007. The aim of the strategy is to improve public transport in South Africa through the establishment of the Integrated Rapid Public Transport

Networks (IRPTN) in the form of priority rail corridors and BRT with the longer-term vision being “to develop a system that places over 85 per cent of a metropolitan city’s population within 1km of an Integrated Rapid Public Transport Network trunk (road and rail) or feeder (road) corridor” (Pillay and Seedat 2007, 400). In the city of Johannesburg, the development of *Rea Vaya* is in line with the city’s 2030 Vision and Growth and Development Strategy. According to Goondiwala (2014, 16), the vision regarding transport is:

a safe and efficient transportation system, with a public transport focus that will support a world-class city, connecting businesses, people, and places in a sustainable and cost-effective manner and, through this, improve the standard of living and quality of life of all the city’s inhabitants and the overall competitiveness and growth of the city’s economy.

The viability of the project increased when South Africa won a bid to host the 2010 world cup. This led to the setting up of a Public Transport Infrastructure and Systems grant (PTIS). Signed in 2007, the PTIS grant enabled the fast tracking of the implementation of the BRT system to meet the soccer world cup dates (City of Johannesburg 2012). The Public Transport Action Plan, which supplements the Public Transport Strategy, is based on a phased approach as shown and explained in Figure 1.

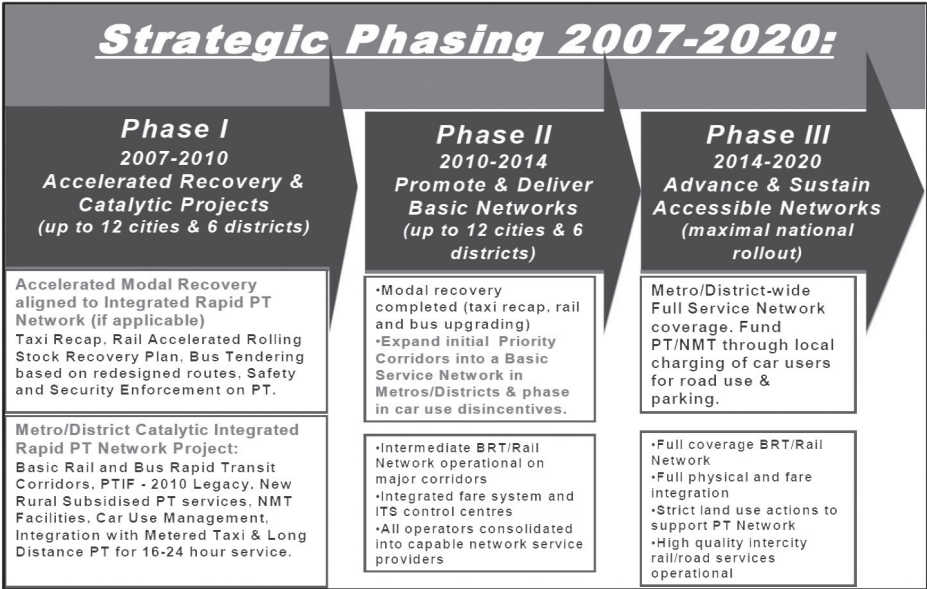


Figure 1. The Public Transport Strategy Phases

SOURCE: Pillay and Seedat (2007, 402).

Research undertaken as part of a Ph.D. project at the University of South Africa (Agyepong 2014) focussed on assessing green procurement

practices of goods and services in metropolitan municipalities in South Africa. The City of Johannesburg is one of the municipalities studied, and procurement practices as part of *Rea Vaya* were also included. The study documents some of the *Rea Vaya* green technologies including easy access double-sided door buses, use of a cashless system, station monitoring through the use of CCTV (closed circuit television) cameras, and GPS (Global Positioning System) bus monitoring.

Another study by Rahim (2014), also undertaken as part of an M.Sc. study at the University of South Africa, focused on the social and economic effects of the *Rea Vaya* system on selected stakeholders in Johannesburg. The study employed qualitative surveys and in-depth interviews to collect data from the perspective of BRT stakeholders. The findings revealed differences in opinions among stakeholders with those using the systems mentioning benefits like enhanced bus frequency and reduced travelling time, though some complained that communication was not efficient and they were sometimes forced to revert to other modes of transport because of that. Bus fares were considered to be affordable though some commuters were not satisfied with the administration fee that is charged when they load money into smart cards. Reliability, safety, and cleanliness also came up as advantages of the *Rea Vaya* system over other public transport modes even though some of the respondents did not agree to this. Other stakeholders like motorists and taxi operators felt that the use of dedicated lanes by *Rea Vaya* increased congestion (for motorists) and gave the BRT an unfair advantage (for taxi operators).

Data for the study by Rahim (2014) was largely based on Phase 1a of the system and was collected just after the launch of Phase 1b (Figure 1). Some of the recommendations that it makes, for example, integration of different modes of transport and use of feeder routes to enhance accessibility of *Rea Vaya* to commuters, have since been implemented. Furthermore, the study relied on a very limited sample of the stakeholders (only 125 participants), which is not at all representative of the total number of *Rea Vaya* stakeholders.

An appraisal of the system was undertaken by Vaz and Venter (2012), who assessed the effectiveness of *Rea Vaya* in terms of poverty reduction. According to Vaz and Venter (2012), *Rea Vaya* replaced 580 minibus taxi vehicles (585, according to Goondiwala 2014) that were operating between Soweto and the Johannesburg CBD (Central Business District), which has seen the BRT become the second largest public transport operator with a market share of 30% (the market share for taxis is 39%). They documented main the benefits of the system including time and cost savings (10 to 20%), community satisfaction in terms of social cohesion, and access to a variety of activities. Their research was, however, undertaken two years after implementation and their findings may be different from the current situation since there has been further implementation of the system. Furthermore, their focus was not on green technology implementation, but

on the effectiveness of the BRT system as part of the poverty reduction strategy.

From the reviewed research, the most recent article was published in 2014 (Goondiwala 2014). The research documents the socio-economic and environmental benefits of the system as follows (Goondiwala 2014, 17):

- efficient, reliable, and frequent public transport services;
- affordable fares;
- a safe and secure public transport system;
- accessible public transport for people with disability, mothers with children, and the elderly;
- a decrease in traffic congestion, energy consumption, and vehicle emissions;
- an enhanced urban environment; and
- job creation and income generating opportunities.

These benefits are comparable to other BRT systems at international levels. An example is the TransMilenio BRT system, which was implemented in Bogota, Colombia, in 1998, where benefits like reduced travelling time, cost savings, reduced accidents, amongst others, were also realised (Hidalgo, Pereira, Estupiñán, and Jiménez 2013).

This chapter makes an attempt to go further than current research by discussing accrued benefits mostly in terms contribution to the green economy since the implementation of the system in 2009 until 2015. It also evaluates the relative advantage (Rogers 2003) of the benefits over and above a *business-as-usual* scenario.

2. Statement of the Problem and Study Objectives

Because of an apartheid history, most of the people constituting the working class in South Africa live in dormitory towns far away from their workplaces. They still commute to and from work on a daily basis, and many of them rely on an inefficient public transport system, which is still largely dominated by privately-owned taxis. There is still a need to improve population mobility for access to work, especially in big towns like the city of Johannesburg. The challenge is that the transport sector is one of the biggest sources of carbon emissions, and, in South Africa, it comes second after the energy sector. It is, therefore, naturally one of the priority sectors that the country should focus on, in introducing climate change mitigation strategies. The introduction of the Bus Rapid Transit system presents an opportunity to achieve a double-barrelled objective of enhancing mobility while at the same time reducing greenhouse gas emissions from the transport sector. Very few studies have so far focussed on green technologies implemented as part of the BRT system and the advantages they bring about in a holistic manner. This chapter, therefore, focuses on documenting the green technologies and/or innovations that have so far been implemented as part of the BRT system, which help to improve the

efficiency of the sector while at the same time contributing to climate change mitigation through reduction in greenhouse gas emissions.

The main objective of the study is to showcase and demonstrate the relative advantage (Rogers 2003) of the green technology/initiatives that have been implemented as part of BRT in South Africa in Johannesburg. The specific objective is to assess the contribution of the green innovations to transport efficiency (a social effect) and to the green economy (an economic and environmental/ecological effect). This will be done by assessing the advantages that have accrued and/or are accruing in terms of promoting sustainable development, which would not have been realised if the BRT was not implemented in Johannesburg.

3. Theoretical Framework, Research Design, and Methods

3.1. Theoretical Framework

This chapter is informed by the ‘diffusion of innovations’ theory. The theory, promulgated by Everett Rogers (2003), seeks to explain the process by which an innovation is adopted, specifically how, why and at what rate (see Rogers 2003). Rogers (2003, 5) defines diffusion as “... the process in which an innovation is communicated through certain channels over time among the members of a social system”. According to Robinson (2009), the main feature that distinguishes the approach of the ‘diffusion of innovations’ theory from other theories of change is that focus is not on the recipients of an innovation, but rather on the innovation itself, which should evolve to better fit the needs of society.

The qualities that influence the success of an innovation were given as innovation-communication channels, time, and social system or context (Rogers 2003). The focus of this chapter is on the innovation which Rogers (1997, Unpaginated) describes as “an idea perceived as new by the individual”. Five characteristics are said to be the determinant factors of the rate of adoption of an innovation. These are explained by Rodgers (1997, Unpaginated) as:

- **Relative advantage:** the degree to which an innovation is perceived as better than the idea it supersedes;
- **Compatibility:** the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters;
- **Complexity:** the degree to which an innovation is perceived as difficult to understand and use;
- **Trialability:** the degree to which an innovation may be experimented with on a limited basis; and
- **Observability:** the degree to which the results of an innovation are visible to others.

Of interest to this chapter is the concept of 'relative advantage'. Relative advantage is basically determined by the nature of the innovation. It is categorised into two types: preventive and incremental (non-preventive) innovations. A preventive innovation, which is the category the innovations considered in this chapter fall under, is defined as "a new idea that an individual adopts now in order to lower the probability of some unwanted future event" (Rogers 2003, 233). Rodgers (1983) mentions some of the dimensions of relative advantage as economic and social, among others. In this chapter, relative advantage is considered in terms of the aims of the green economy which are encapsulated within the concept of sustainable development and are integrative of climate compatible development. The analysis and discussion of the findings in light of the concept of relative advantage will be based on the dimensions of sustainable development, that is, environmental (ecological), social, and economic factors.

3.2. Research Design

A qualitative research design was found to be the most relevant to this research. Qualitative research basically endeavours to interpret and understand phenomena and/or local processes within their contexts (Maxwell 2005). According to Leedy and Ormrod (2012), it facilitates description, interpretation, verification and evaluation of phenomena and situations. Through enabling description, qualitative research "can reveal the multifaceted nature of certain situations, settings,... relationships, systems", etc. while evaluation is the means through which researchers "can judge the effectiveness of particular policies, practices or innovations" (Leedy and Ormrod 2012, 140). The qualitative design was, therefore, found to be relevant because the research sought to investigate and, through description, develop an understanding of green technologies that have been implemented as part of *Rea Vaya* BRT. It is the most suitable design to divulge the information in response to the questions that the study sought to answer, particularly since it enables "richness and intensity" of detail (Nicholls 2011) to be maintained. In addition, the collected information is of a qualitative (and not quantitative or measurable) nature. The research was also aimed at evaluating the relevance of the green technologies implemented as part of the *Rea Vaya* BRT system to climate compatible development through reduction in emissions and also in terms of other socio-economic impacts – an exercise which also generates qualitative information.

The research was designed as a case study. Case study research enables "in-depth investigations of one or more examples of a current social phenomenon" (Jupp 2006, 20). Because focus is only on one example of the phenomena under study, case study approach enables an in-depth description and analysis of the phenomena. A case study approach was adopted to enable the development of an in-depth/detailed account of *Rea Vaya* BRT technologies. In addition, the research was of a limited scope and available time was only adequate for a case study.

3.3. Methods

Case study researches are not prescriptive of data collection techniques; which means that they are compatible with all data collection techniques (Merriam 2001). However, they are primarily designed as qualitative researches (Gillham 2000). In this study, data was collected using a variety of methods including review of literature, documentary research, and website content analysis. Such qualitative methods are also aligned with a qualitative research design.

Literature review involves critical review of scholarly work which can be in the form of published scientific reports. It was done to gather background information, to contextualise the study, and to develop a justification for the research. It enabled to position the chapter within the current literary debates in the field and to identify and define the research gap that the chapter is addressing. Literature review also helped to provide the basis upon which a critical discussion of the technologies was based.

Documentary research involves the *systematic* collection of data about a phenomenon through analysis of documents so as to develop a better understanding of the phenomenon or to understand patterns that characterise it (Mogalakwe 2006). Sources of information for documentary research could be newspapers, census reports, or government documents, to mention a few. In this research, documentary research was undertaken to gather information on green technologies implemented as part of the BRT system and the benefits thereof. In the case of this study, online news from the *Rea Vaya* online news archive were reviewed. The study mainly relied on the *Rea Vaya* news archives because the articles were most likely to be authentic as they are held on *Rea Vaya*'s own official website. The documents were also found to contain comprehensive information regarding the implementation of *Rea Vaya* and its progress with time. The bulletins basically communicated information regarding progress with the *Rea Vaya* project and reported on transport events where the *Rea Vaya* project was discussed. The research focussed on news bulletins from 2009, which is the year *Rea Vaya* was launched, up until the latest 2015 bulletin that was online as of 30 March 2015.

Qualitative content analysis of the documents was undertaken to extract the information relevant to the research. Cohen *et al.* (2007, 475) defined content analysis as "the process of summarising and reporting written data – the main contents of data and their messages". In the context of this study, content analysis helped to extract information on green technologies/innovations. The information on relative advantage was organised based upon contribution towards the three main sustainable development themes, i.e. social, economic, and ecological sustainability. This was also a way of coding/sorting the data.

An inductive approach was employed to analyse the data. Induction entails developing conclusions (theory) from observations with the intention of

generalising the findings to a larger population (Danermark *et al.* 2002). This approach was chosen because it allows data ‘to speak for themselves’ and, therefore, enable more relevant results as opposed to making *a priori* assumptions (Brewer 2003). This enhances data reliability and validity.

3.3.1. Validity and Reliability

Data validity and reliability was addressed in two ways. First, it was in-built in the selected methods of research. The fact that the study was a case study enabled the development of technology descriptions that are more detailed. There is also high likelihood that information sourced from official websites is authentic and, therefore, reliable. Secondly, theoretical saturation (Glasser and Strauss 1967) was also one of the indicators of data reliability that the study depended upon. This entails continued extraction of information from data sources until no new information is being generated. In the context of this research, all the news archives between 2009 and 2015 were collected and exposed to content analysis until data ended up being repetitive and no new information was emerging.

While care was taken to ensure reliable results, the main limitation of the research is that it is based upon a case study and, hence, the results may not be representative of BRT systems in South Africa. In addition, documents, which the research relied upon, may not necessarily be up to date, especially with most recent developments.

4. Results and Discussion

4.1. Description of *Rea Vaya* BRT and the New Technologies/Innovations

Rea Vaya is the City of Johannesburg’s flagship public transport project and is an initiative which was developed with the aim of reducing GHGs as one way of climate change mitigation. As mentioned in the introduction, the *Rea Vaya* BRT project was planned in phases. Phase 1 started operating on 30 August 2009, with full operation across all the envisaged phases expected by 2015. Eventually, the bus is expected to run along 330km dedicated routes, which will ensure that residents are within 500m of a bus route or feeder corridor and will enable more than 80% of the residents of Johannesburg to catch a bus (*Rea Vaya* 2014a). Latest statistics online on the *Rea Vaya* website show that the BRT has 48 stations and 10 median key stations along trunk routes which stretch for 59 km. In total, the bus fleet is 277 while Phase C will have between 240 and 260 buses.

In terms of road infrastructure, *Rea Vaya* is comparable to systems like Bogota’s TransMilenio, which has a combination of trunk and feeder routes; Bogota’s TransMilenio also has level boarding, uses an advanced fee collection system, and relies on a centralised control system (Hidalgo *et al.* 2013). The *Rea Vaya* BRT system has dedicated bus lanes in the middle of the road. Figure 2 is a comprehensive route map for the bus. The bus routes are composed of trunk routes (red colour), complementary routes

(turquoise), and feeder routes (yellow). As can be seen from the map, trunk and complementary routes connect the CBD and Soweto, with a relatively dense network of trunk routes being in the CBD. In Soweto, most of the routes are feeder routes. Table 1 provides a key to these colour-coded operational routes.

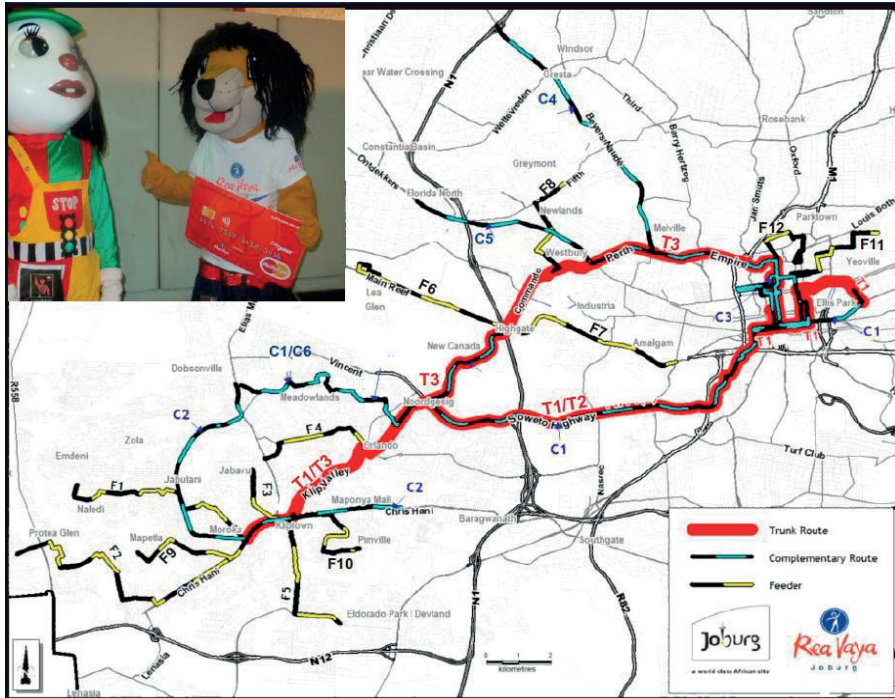


Figure 2. *Rea Vaya* route map

SOURCE: Adapted from *Rea Vaya* (2014b).

The *Rea Vaya* bus network is also integrated with other public transport networks and “is designed to feed into a high volume trunk service” (Goondiwala 2014, 18). The other networks include Gautrain, Metrorail, bus routes, pedestrian corridors and taxis (*Rea Vaya* 2014a). Figure 3 demonstrates how *Rea Vaya* is integrated with Gautrain and Metrobus, which are the other public transport systems.

Table 1. *Rea Vaya* operational routes

Trunk routes	Complementary routes	Feeder routes
T1: Thokoza Park to Ellis Park	C1: Dobsonville to Ellis Park East	F1: Naledi to Thokoza Park
T2: Thokoza Park to Braamfontein via Soweto Highway	C2: Ndingiliza to UJ Soweto Campus via Maponya Mall	F2: Protea Glen to Thokoza Park
T3: Thokoza Park to Parktown and Library Gardens East	C3: Inner City Route	F3: Jabavu to Lakeview
	C4: Windsor West and Cresta to Parktown and Inner City	F4: Mofolo to Boomtown
	C5: Florida North to Parktown and Library Gardens	F5: Eldorado Park to Lake View
	C6: Dobsonville to Bosmont	F6: Lea Glen to Bosmont
		F7: Amalgam to Bosmont Station
		F8: Westbury Station to Greymont
		F 9: Mapetla to Thokoza Park
		F10: Pimville to Lakeview
		F11: Bellevue/Yeoville to City
		F12: Parktown distribution route

SOURCE: Adapted from (*Rea Vaya* 2014b).

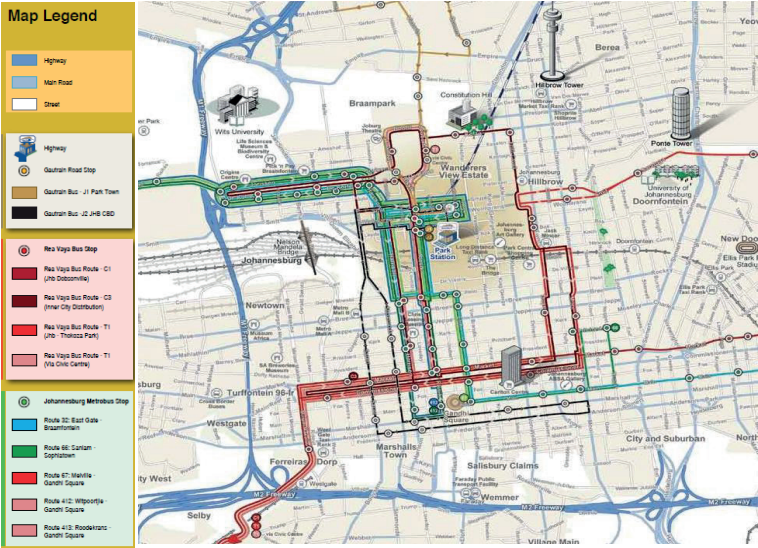


Figure 3. Park Station Integrated MapSOURCE: City of Johannesburg Transport Department (n.d.).

Rea Vaya buses are dual fuel buses which run on low sulphur diesel. Plans are also underway to purchase buses that can use a combination of diesel and biogas (Goondiwala 2014). The buses have a high floor surface design, which is in line with the station level to enable easy boarding. Figure 4 shows one of the buses parked by one of the bus stations. Note the raised platform of the bus station.



Figure 4. A *Rea Vaya* bus parked at one of the stations

SOURCE: *Rea Vaya* (2015a).

The buses accommodate between 75 and 112 passengers (*Rea Vaya* 2010). The 13m buses have two doors while the articulated buses (18m) have three doors (Goondiwala 2014), which also facilitates quick boarding and disembarking. The stations are also accessible from both sides through electric doors, and passengers can open them by swiping their smart cards while bus drivers open them when they dock (*ibid.*). The buses and stations have fixtures and fittings which accommodate people with various disabilities. The details are captured in Box 1.

Rea Vaya buses and stations incorporate a number of features to cater for people in wheelchairs, for commuters who are visually- or hearing-impaired, as well as for the elderly and pregnant women. People in wheelchairs will find the areas surrounding *Rea Vaya* Stations evenly paved, and the stations all fitted with access ramps of a width and gradient that conforms to universal guidelines. For those with mobility challenges, the ramps have handrails on either side, and a landing area halfway up for those who wish to rest. To guide visually-impaired commuters, the ramps have lights on both sides, while for the hard-of-hearing, each station has an electronic variable message system in different languages. At the ticket booths, the window height has been adjusted to accommodate people in wheelchairs, while the booths themselves have enough space for people in wheelchairs to work in. The station platforms and bus doors are level with each other, making boarding and exiting *Rea Vaya* buses a simple matter (multiple doors also speed up boarding and alighting) while the bus interiors come with a number of features designed for passengers with disabilities.

Box 1. Disability-Friendly Features of the *Rea Vaya* BRT System

SOURCE: *Rea Vaya* (2014c).

Rea Vaya bus stations have a battery system to back up electricity. The battery system can last up to 6 hours. As part of their design, they do have solar panels on the roof which are also used for generating energy to back up electricity (*Rea Vaya* 2013). Figure 5 is a picture of a *Rea Vaya* bus station.



Figure 5. One of the *Rea Vaya* bus stations
 SOURCE: *Rea Vaya* 2014b.

As can be seen from Figure 5, the bus stations are also designed to enable natural light and ventilation (Goondiwala 2014), which also reduces reliance on electricity.

The depot for *Rea Vaya* is in Dobsonville, Soweto, and that is where the maintenance of the buses takes place. The depot has an oil and water separator, which is used to separate oil and water drained from the buses (*Rea Vaya* 2013). Future plans are to build another depot in Booysens, south of Johannesburg, and two others in Alexandra and Ivory Park as part of Phase 1C of the project.

The buses operate on a daily basis running from 5am to 9pm from Monday to Friday and from 5am to 6pm on Saturdays and Sundays. During peak hours on weekdays, the bus frequency is 3 to 5 minutes. The frequency changes to a 15-minute interval during off-peak hours. The bus frequency is 30 minutes during weekends (Saturdays and Sundays) (*Rea Vaya* 2014b).

The bus service is cheap and affordable and the charged fares are comparable to those charged by the public taxis. Table 2 is an outline of the fares currently posted on the *Rea Vaya* website.

Table 2. *Rea Vaya* bus fares

<i>Rea Vaya</i> Journey length	Fare (Rands (ZAR))	Fare (US\$) Rate: 1US\$: R12.36 (as at 17 July 2015)
0–5	5.50	0.44
5.1–10	7.20	0.58
10.1–15	9.00	0.73
15.1–26	10.70	0.87
26.1–35	12.50	1.01

SOURCE: Adapted from *Rea Vaya* 2014b.

The collection of bus fares is done through the use of smart cards. The smart cards are quick and easy to use and they calculate and deduct a fare only for the distance travelled and are re-usable. Fares can be topped up at any of the *Rea Vaya* stations, through vendors and retail outlets as well as at ABSA Bank ATMs. One can load up to R3000 (US\$243) and the cards can be used in stores to pay for goods (R200 or US\$16 per transaction). Money can be transferred from an old card to another one if a card is reported stolen (*Rea Vaya* 2014b).

Security in *Rea Vaya* buses, including at the bus stations, is monitored via CCTV cameras linked to the control centre. The *Rea Vaya* control room is equipped with state-of-the-art technology which enables quite a number of things (*Rea Vaya* 2009a), including:

- monitoring traffic lights, traffic incidents, and road conditions and giving BRT buses the right of way at intersections if they are running more than three minutes late;
- allowing automatic fault reporting related to the buses and stations. This enables timely dispatching of technicians when there is an incident with a bus to either rectify the problem or remove the bus from the road;
- automatic vehicle locators (GPS) to track buses;
- a driver management system to manage drivers' handling of the buses; and
- bus-scheduling systems which allow the control centre to schedule buses and operators to schedule their drivers.

Quite a number of jobs have also been created from the development of *Rea Vaya* BRT system. Box 2 sums up already created jobs and those anticipated until full implementation of the project.

Box 2. Employment creation due to *Rea Vaya* implementation

- 5,700 jobs will be created during the construction phase, and for every one job created in construction, another two are created in the cement, iron, and steel industries.
- 340 permanent jobs have already been created in the first bus operating company and some 200 more jobs will be created in the second bus operating company, with a possible 500 more in Phase 1C; some of these jobs will replace jobs in the taxi industry.
- 488 jobs to date have been created at stations and, on average, 1000 more jobs will be created at stations and interchanges, for ambassadors, marshals, cashiers, and cleaning and security staff through Phase 1C.

SOURCE: *Rea Vaya* (2015b).

In addition to the created jobs, *Rea Vaya* has also enabled the realisation of black economic empowerment through absorbing former minibus taxi operators as shareholders. As many as 585 taxi drivers were taken off the

road and were employed by *Rea Vaya* BRT either as bus drivers or to work at the stations (City of Johannesburg 2012). Integrated within job creation was empowerment of some of the employees through training. Drivers, including those from the taxi industry, went through a month-long training programme which focussed on a variety of skills including driving skills, procedures to dock at the *Rea Vaya* stations, how to use the bus equipment, and customer care (*Rea Vaya* 2009b).

4.2. Discussion

As mentioned in the methodology, the other objective of the study, besides showcasing the *Rea Vaya* innovations, was to discuss the relative advantage (Rogers 2003) of the innovations or new technologies implemented as part of the *Rea Vaya* BRT, especially within the concept of climate compatible development. The discussion of the findings is based on the dimensions of sustainable development, and the technologies will, therefore, be clustered according to these themes.

4.2.1. Environmental Dimension

From the results, there are a number of innovations which reflect that the development and implementation of *Rea Vaya* is aligned with climate compatible development, particularly in terms of minimising carbon emissions and, therefore, climate change impacts. These are as follows:

- The dual fuel design and use of low sulphur diesel
- Oil and water separation during bus maintenance
- Use of dedicated roads
- Technology that enables automatic fault reporting
- Natural light and ventilation and solar power back-up system at stations, and
- Fare collection

Environmental wellbeing and especially promoting a low-carbon economy has been a focus of the *Rea Vaya* BRT system from the beginning. *Rea Vaya* BRT has, therefore, been regarded as a decisive response to climate change and is said to be the “single largest climate change initiative ever undertaken by the city and ... a major turning point in how it (the city) deals with congestion, pollution and greenhouse gases caused by transportation” (*Rea Vaya* 2014d).

While this research did not investigate the overall savings that have accrued from the dual fuel technology and the use of low sulphur diesel so far, the reality is that greenhouse gas emissions from low sulphur diesel are much less compared to other fuel types. The buses are considered the cleanest on the African continent. Reduction in emissions, though not measured, will also have accrued from the replacement of some of the minibus taxis with *Rea Vaya* buses (Vaz and Venter 2012). It is projected that a modal shift by 15% of motorists from private cars to *Rea Vaya* could reduce carbon emission by 1.6 million tonnes by 2020 and will, in addition, reduce related

emissions like nitrous oxide and soot by thousands and hundreds of tonnes (respectively) annually (*Rea Vaya* 2014d). However, research by Vaz and Venter (2012) indicated that no modal shifts from cars to *Rea Vaya* had taken place by early 2011. While their sample size was only 150 households, this is cause for concern, especially because the success of the system in climate change mitigation is highly dependent on such a modal shift.

The *Rea Vaya* depot in Dobonsville Soweto, where the maintenance of the buses takes place, recycles used oil from the buses. This is another contribution, albeit in a small way, to environmental wellbeing as it reduces dependence on raw oil. Emissions that are saved in this case are those associated with the value chain as recycling reduces the need for extraction of more oil (*Rea Vaya* 2013).

The use of dedicated roads helps to reduce traffic congestion, which in turn helps to reduce the contribution of the buses to emissions. This is further made possible by the real time reporting of faults that is again made possible by the modern control room technology, which ensures that there are not many delays along *Rea Vaya* bus routes. As a result, the contribution of *Rea Vaya* buses to congestion and, hence, to emissions is comparatively lower in relation to other modes of transport which do not have dedicated lanes. This advantage is likely to be enhanced if modal shift occurs from other road transport systems which will reduce the number of these other vehicles on the road.

The green design of the bus stations also helps reduce emissions. This is because they enable natural light and ventilation and, hence, there is less consumption of electricity. Most of the electricity in South Africa is generated from coal, which is a dirty source in terms of emissions (Togo 2014). Reduction in reliance on electricity, therefore, means a reduction in the amount of coal that is burned to generate that electricity. Emission savings also accrue whenever the stations rely on the back-up solar energy. This is likely to happen given the recent periods of load-shedding in the country. The electronic fare collection system also reduces the use of paper tickets. However, as mentioned before, users of the system are not all happy due to administration fee charges (Rahim 2014).

Overall, *Rea Vaya* BRT does contribute to reducing emissions and, hence, to reducing climate impacts, particularly from the dual fuel green design and the use of low sulphur diesel. As mentioned earlier, carbon emissions per passenger kilometre are very low when a bus transports as few as 3 people compared to having them drive their own cars (Stanley and Watkiss 2003, as cited by Chapman 2007). Modal shifts have already taken place especially with the initial withdrawal of 585 minibus taxis, which were replaced by only 143 buses (Goondiwala 2014). What may need to be explored is the use of double-decker buses, which Chapman (2007) argues, can replace as many as 50 buses. Even though the study did not collect data to show how far the system has reduced emissions, it is clear that *Rea Vaya*

green technologies are advantageous in terms of environmental wellbeing and contribute to reducing climate impacts compared to pre-existing modes (predominantly Metrobus and minibus taxis), which did not have such technologies. It is by this virtue that Metrobus is also considering greening its fleet through the use of biogas.

4.2.2. Economic Dimension

As mentioned in the results section, BRT enabled black economic empowerment through absorbing as shareholders some of the minibus taxi owners who were originally operating the routes that *Rea Vaya* BRT is now operating. This is strategic in terms of black economic empowerment, especially considering the history of apartheid, which disempowered the black majority. There was no investigation to find out the net job effect (jobs lost versus those created) of the absorption of the taxis by the BRT. However, in the case of Bogota's TransMilenio, the result was a positive net job effect where more jobs were created than those which were lost (Hidalgo *et al.* 2013). While the study did not investigate the actual income of the drivers or the annual income generated by the shareholders as compared to what they were getting before joining *Rea Vaya*, Goondiwala (2014) reports ticket revenues to be in the range of R4.3 to R6.5 million per month.

In addition to that, *Rea Vaya* has also generated a lot of direct jobs and some of them influenced job creation in industries which are part of *Rea Vaya*'s value chain. Creation of jobs means that people who would otherwise be unemployed are able to earn a salary at the end of each month. Goondiwala (2014) reports that employees realised a significant increase to their incomes with the added advantage that they are now formally employed, work formal hours, and have the benefits that go with formal employment, e.g. insurance, medical aid, and a pension. This is an economic contribution which was only made possible because of the *Rea Vaya* project and is an advantage over the previously existing status quo.

Rea Vaya passengers have also benefited economically from using the BRT system compared to the modes of road transport they were using before. This is through cost savings. Vaz and Venter (2012) carried out a study to assess the effectiveness of *Rea Vaya*. They reported cost savings of between 10 to 20%; however, they argue that these are still higher than the cost of travelling by rail and were accruing mainly to the middle-income group as lower income earners preferred to use the rail system, which is cheaper than *Rea Vaya*.

Job creation (specifically green jobs) is also one of the aims of the green economy. *Rea Vaya* BRT has made a huge contribution and brought about economic advantages over and above the existing status quo where there are higher chances that many of the current employees were unemployed.

4.2.3. Social Dimension

Rea Vaya BRT also has many social advantages compared to the Metrobus and minibus taxi, the pre-existing public transport modes. According to Goondiwala (2014), social cohesion is the greatest impact of *Rea Vaya* BRT system through making the CBD more accessible to the Sowetans. She argued that this is evidenced through the increase in ridership, which was around 63, 000 passengers and has risen to 1.1 million passengers per month. Accessibility to jobs has, therefore, increased and this was confirmed by Vaz and Venter (2012).

Equity of access to transport is another advantage. The raised platform of the bus station, which complements the high floor surface design of the buses, the fixtures at the stations, and even the paving made it accessible to disabled people and other disadvantaged groups like pregnant women and the elderly and/or the ailing. This is an advantage which the mentioned groups of people did not enjoy when using public transport to travel in Johannesburg before the implementation of BRT.

General accessibility to transport has also been enhanced due to *Rea Vaya* BRT. Besides the network of feeder routes which connect to trunk routes, the fact that the system is integrated with other modes (e.g. Gautrain and Metrobus) enables passengers to easily shift from one mode to another. Time savings have also been realised (Vaz and Venter 2012).

Safety is also another social advantage that *Rea Vaya* BRT has over the pre-existing status quo. BRT enables this in two ways. One way is through the monitoring from the control room of the bus stations and the buses. The other way is through dedicated bus lanes which reduce road traffic accidents. Incidences recorded in 2011 from operating 4.8 million km were 227 and out of that number, only 17 were accidents during which only two deaths occurred; the rest were minor damages and scratches to the buses (Goondiwala 2014). This makes the accident rate to be 4.7 and the injury rate to be 0.35 per 100 000km, which Goondiwala (2014, 18) argues, are comparable to international systems, which in turn shows that *Rea Vaya* has “a world-class public transport system in terms of safety”. The other dimension of safety is enabled through the use of smart cards, which means that passengers do not carry around cash on themselves, thus reducing the possibility of being robbed.

Overall, Vaz and Venter (2012, 1) argue that *Rea Vaya* BRT “makes a modest contribution to community satisfaction with transport”. It should be noted, however, that the system infrastructure is still relatively new and may, therefore, be easy to maintain. In the case of TransMilenio, satisfaction levels were high when the infrastructure was new, but they dropped with time due to poor infrastructure maintenance (Hidalgo *et al.* 2013). Maintaining and/or improving the satisfaction levels into the future will partly depend on whether the infrastructure is well-maintained or not.

5. Conclusion and Recommendations

As discussed in the methodology, relative advantage basically refers to the extent to which an innovation is perceived to be better over and above existing ideas. There have not been many studies on the Johannesburg BRT system which explore its relative advantage. From the available literature, the system comes through as advantageous in various aspects compared to pre-existing modes or public road transport in terms of the objectives of the green economy. Implementation of the system is still underway and these advantages are expected to increase in future. For that to happen, there is a need to make sure that the infrastructure is well-maintained and remains in a good working condition. Concerted efforts are also required to ensure a shift from use of cars to use of the BRT system for the projected reduction in GHG emissions to be met. More positive impacts could also be realised if there was complete reliance on solar energy at *Rea Vaya* stations. This is something that can be explored further to determine the feasibility of such a shift.

This study was based on secondary data. This is because the main aim was to showcase the implemented green technologies, and the information is already in the public domain. The discussion on relative advantage relied mostly on projections and a few studies that have been done to investigate the early impacts of the system. Future research can focus on collecting primary quantitative data to measure the extent to which emissions are being reduced through the use of *Rea Vaya* compared to other modes of transport.

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CHAPTER FIVE

Rural Women's Participation and Investment in Renewable Energy as a Low-Carbon Adaptation Strategy: Evidence from the Sustainable Energy Project in Malawi

Charity Chonde and Harriet Chiwaula

Abstract

The study investigated rural women's participation and investment in low-carbon adaptation strategies in southern Malawi. A mixed-methods approach was employed. A checklist and semi-structured interviews were used in focus groups and household survey, respectively, to collect data. Content analysis was employed to analyse qualitative data. Logit regression analysis was used to determine factors that influenced rural women to invest in energy-efficient low-carbon cooking stoves. The study determined that beneficiary women participated in sustainable energy project activities, namely, micro businesses, village savings and loans, afforestation, community-based forest management and adult literacy programmes. The study further found that there were significant differences between beneficiary and non-beneficiary women in their participation in income-generating activities. This suggests that development projects boosted the capacity of rural women to engage in economic activities that improved their livelihoods. Findings suggested that access to clean energy-efficient stoves was vital to rural women as it reduced time burden for collecting firewood used in cooking and heating; promoted health and nutrition; and supported livelihoods as they had extra time to engage in economic enterprises and capacity building through participation in adult literacy programmes and other trainings. This paper contends that limited access to energy by rural women further impoverishes them and increases their workload. This, in turn, has negative impacts on the country's economy since women participate less in economic activities with reduced time to earn income and less means to productively use the money they earn. The study determined that the sex of household heads, the price of cooking stoves, the age of women, the attitudes of households, and beliefs about environment and household size influenced rural women's investment in energy-efficient low-carbon cooking stoves.

Keywords: Adaptation, climate change, gender, participation, sustainable energy

1. Introduction

Globally, climate change has been recognised as one of the biggest challenges facing humanity. It is scientifically accepted that human-induced climate change, through increased CO₂ and other greenhouse gas emissions and through depletion of CO₂ capture by deforestation, play a major role in

exacerbating its impacts (GoM 2008). The Government of Malawi recognises that global climate change has serious implications for the country. Malawi's unique and fragile ecosystems are particularly vulnerable to the impacts and effects of climate change, thereby negatively affecting the livelihood of Malawians. This vulnerability is exacerbated by Malawi's socio-economic and demographic factors such as slim economic base, dependence on rain-fed agriculture, greater reliance on biomass energy, and low adaptive capacity at the community and national levels (GoM 2013a).

The Government of Malawi developed a national policy on climate change in 2012, which guides actions that reduce community and ecosystem vulnerability through adaptation and mitigation. The policy also guides harmonised approaches by different sectors and institutions towards building community and ecosystem resilience to climate change. The policy also leads the country to benefit from the global financial, technical, and technological opportunities arising from the desire of the international community towards low-carbon development. Examples of technological opportunities include investment in renewable and environment-friendly energy alternatives (GoM 2013b). The Government of Malawi recognises that renewable energy sources such as small hydro, wind, biomass, biogas, geothermal, and municipal wastes have the potential to increase the power supply and diversification of electricity generation sources in Malawi as well as improving income and employment through improved livelihood opportunities (GoM 2009). Communities which are at a distance from the existing grid stand to benefit from renewable energy which, in addition to being clean, is locally available (CES and MuREA 2014).

A number of organisations have undertaken to assist local communities to invest in renewable energy as a low-carbon adaptation strategy in Malawi. One such organisation is Concern Universal, which implemented a 5-year sustainable energy project in Balaka District, a drought-susceptible area which is typified by poverty and high levels of deforestation. It is affected by floods and windstorms that result in loss of livelihoods and housing. The project, which was completed in 2012, worked with 180,000 people in 321 villages to improve sustainable access to and use of energy. Project activities included the introduction of solar technologies, the production and marketing of clean-fuel-efficient stoves called *Chitetezo mbaula*, afforestation, and micro-businesses. In total, 24,000 fuel-efficient cooking stoves were sold and were in use by the time the project terminated. This study, thus, investigated rural women's participation in the project and the determinants of investing in energy-efficient cooking stoves as a low-carbon adaptation strategy.

1.2. Statement of the Problem

In spite of efforts over the years, a significant proportion of humankind still does not have access to modern and even sufficient energy. Approximately, 1.3 billion people do not access electricity and 2.6 billion yet do not have

access to clean cooking energy. The majority of these disadvantaged people reside in the developing countries. The energy position of this group has repercussions for their human, economic, and social development. The generation and dissemination of climate-compatible technologies can play a vital role in the mitigation of this situation, often resulting in development and climate benefits (Karekezi 2002). Development is not possible without access to energy, and energy is vital for women's development in terms of reducing their time burden for collecting firewood used in cooking and heating, supporting livelihood activities, improving health and wellbeing, and providing opportunities for enterprise and capacity-building. Studies show that many rural women spend up to three hours a day gathering fuel and carrying heavy loads. This burden leaves them with little time for productive activities or leisure, and can put women and girls at risk of long-term health problems and increase their vulnerability to physical or sexual violence. The provision of energy-efficient low-carbon cooking stoves can mitigate these negative impacts while promoting women's empowerment, as the time that would have been used to collect fuel can now be used for other productive and economic activities (IUCN 2004, Gradl and Knobloch 2011). Clean cooking stoves and renewable energy in rural areas are examples of technology innovation processes that can be organised so as to advance the development and deployment of climate-compatible technologies to help meet the energy needs of the world's poor and marginalised populations (Sagar 2013). After the sustainable energy project has been implemented, there has not been an empirical study conducted to investigate the factors that influenced rural women to invest in energy-efficient low-carbon cooking stoves and whether their participation in the project enabled them to engage in activities that improved their livelihoods.

1.3. Research Methods

In order to assess whether participation in the project allowed rural women to engage in activities that promoted their livelihoods, the study drew samples from both project beneficiary areas and non-beneficiary areas. Ten villages (five from beneficiary areas and five from non-beneficiary areas) were selected using probability sampling proportional to size. Households were, then, randomly selected from the ten villages. Moser and Kalton's (1971) adjusted formula was employed to determine sample size whose data would be representative of the population at 0.05 margin of error as follows:

$$\begin{aligned} n &= \frac{n}{1 + \left(\frac{n}{N}\right)} \\ n &= \frac{384}{1 + (384/246)} = 150 \end{aligned} \qquad \text{(Equation 1)}$$

In total, 150 households were randomly sampled, comprising 80 households from 5 beneficiary villages and 70 households from 5 non-

beneficiary villages. In male-headed households, the female spouse was interviewed while the female head was interviewed in female-headed households. A mixed-methods approach in which data were collected through focus group discussions and a household survey was employed. A checklist and semi-structured interviews were used in focus groups and household surveys, respectively, to collect data. Content analysis was employed to analyse qualitative data. A two proportion Z test was used to determine significant differences between two samples. The Logit regression analysis was used to determine factors that influenced rural women to invest in clean-energy-efficient cooking stoves. The logit model takes the form:

$$L_i = \ln (P_i / 1-P_i) = Z_i = Y_i = \beta_0 + \beta_i X_i + u_i \dots \dots \text{(Equation 2)},$$

where:

L_i = the log of odds ratio, which is a linear function of the explanatory variables (X).

$(P_i/1-P_i)$ = the odds ratio in favour of investment in clean-energy-efficient stove— the ratio of the probability that the woman will invest in the cooking stove to the probability that the woman will not.

$Z_i = Y_i = \beta_0 + \beta_i X_i$ represents the (cumulative) logistic distribution function, where:

$i = 1, 2, \dots, 150$.

Y_i = woman investing in clean-energy-efficient cooking stove.

β_0 = the intercept, is the value of the log-odds in favour of investment in clean-energy-efficient cooking stove if the value of X is zero.

β_i = the slope, measures the change in L for a unit change in X; that is, it tells how the log-odds in favour of the woman investing in clean-energy-efficient cooking stove changes as the value of X changes by a unit.

X = is the vector of explanatory variables about the woman such as age, sex of household head, literacy level, membership to VSL, knowledge about amount of firewood saved, price of cooking stove, involvement in income generating activities (IGAs), household size and household involvement in NGO attending to environmental conservation (CONSERVE).

u_i = is the error term.

2. Literature Review

This section presents literature on women's participation in natural resource management organisations and investment in climate-compatible energy technologies.

2.1. Gendered Participation in Natural Resource Management Organisations

Moser (1989) recognised participation in community management as part of the three responsibilities of women, besides the reproductive and productive functions. Moser (*ibid.*) noted that this has shaped the basis for various welfare approaches to women (for instance, mothers' clubs, relief provision, community services or health care) that consider women's organisations as a continuation of their household roles. Other writings and work to group women have centred on information and political empowerment (DAWN 1985). The most important forms of women's organisations for production have been cooperatives and micro-credit programmes. Both of them concern "enlarging the pie" or generating new property. Women's participation in organisations characterised by control over natural resources is difficult because it deals with property rights over existing resources, especially natural resources (Meinzen-Dick and Zwartveen 1998).

Rather than generating new assets, which is a positive sum game for members and does not jeopardise the rights of non-members, participating in natural resource management such as land, water, or forest can be schismatic. For women, as for the vulnerable, to legally demand a right to the resource and assume an active position in its management thus challenges the status quo. At policy formulation level, there appears to be an agreement about the need to take on board women in community organisations for resource management and conservation. Various projects and programmes that engage the organisation of community-based groups do make clear declaration of their aim to assure a certain extent of participation of women. In contrast to the assumptions raised by these policy statements, there is very sparse evidence of clear efforts to increase or promote the participation of women, and still little proof of achievement (Meinzen-Dick and Zwartveen 1998). A large amount of the prevailing literature on natural resource management does not mention gender differences (apart from sporadic obligatory announcements that additional attention is needed) or distinguish between male and female users. Much of the literature that exists is in the form of project reports and gray literature. The gender and environment and eco-feminist literature frequently refers to women as resource managers, but this appears to be largely hinged on the recognition of women as important users of natural resources. If management entails some kind of control over decision making and planning, it is less likely that women are considered as frequently as managers (Jackson 1993).

2.1.1. Recognising Rural Women as Users of Climate-Compatible Energy Technologies

Women's responsibility and interests in climate-compatible energy-technology use and production have been well-documented (Agarwal 1986; Cecelski 1992). Rural women face a crisis of biomass, time, and human energy, both to meet basic human needs and to earn livelihoods. Energy efficiency and especially pricing and availability of alternative fuels continue to be a concern to women in both modernising and developed countries, as women are primarily responsible for cooking and household management in all societies. Labour-saving devices are clearly a priority for rural women, given the inordinate amount of time and energy that they expend in necessary household drudgery (UNDP 1995). For instance, women need renewable energy that is less labour-using, more convenient, and safer to address their critical need for cooking energy. They also need renewable energy to address their labour-saving requirements in water pumping, food processing, grain grinding, and transport (Peskin *et al.* 1992). As entrepreneurs, women need renewable energy to improve profitability and safety in their energy-intensive micro-enterprises, and to save labour. Improved biomass-burning and other stoves, commercial-size solar cookers, solar baking ovens, solar fruit and vegetable dryers, improved fish smokers, and renewable energy-powered grain grinders and millers are some of the applications that have been made to women's food-processing activities. Lighting can also be important for allowing women to work in the evening more productively in home industries (Doraswami 1994; van der Plas 1994).

Rural technology development efforts have endeavoured to deal with two aspects that have had gender implications: those technologies developed to improve production efficiency, and those aimed particularly at minimising women's drudgery. Regrettably, several studies have demonstrated that many labour-saving technological efforts have been futile in saving women's time and energy, and in some cases, even exacerbated women's social and economic conditions. Women producers, who are often part-time and small-scale, can easily be sidelined and, therefore, lose control of the production process to male proprietors who can afford the required capital investment. Even technologies intended to specifically reduce women's drudgery have often not had the most wanted effect because women lack other resources that are required to benefit from these technologies, such as credit, or because interventions did not consider the actualities of the cultural and economic environment (Narayan-Parker 1988).

In order to be successful, projects that assist women entrepreneurs need to pay careful consideration not only to technical feasibility but also to women's capabilities outside the production process, such as access to factors of production (including land ownership and control over cash crops), access to credit, social and cultural context, management and organisation, leadership, and marketing (Sen 1985). Provision of credit and

assisting women's groups in other ways have been the most effective strategies to enable women to own and profit from these larger-scale, more efficient processing technologies (Celceski 2000).

2.2. Investment in Climate-Compatible Energy Technologies

Investment in energy efficiency and renewable energy sources is crucial to reducing greenhouse gas emissions and, therefore, limiting climate change. Global emissions persisted to grow by 44% from 2000 to 2011 (IEA 2013), and policy intervention to alter this tendency is immediately required. Additionally, enhancing the efficiency of energy use and improving the energy production from renewable sources is indispensable to produce the needed progress. Through the uptake of energy efficiency measures and renewable energy technologies, households can make a valuable contribution to minimising greenhouse gas emissions. Literature shows that investment in technology is determined by such factors as the households' socio-economic characteristics, the characteristics of their dwellings, attitudes regarding environmental problems or energy saving measures, knowledge of households about their energy consumption or the cost and performance of energy conservation measures and renewable technologies, along with policy and economic contexts such as available subsidies and energy prices (Poortinga *et al.* 2003; Sardianou 2007; Mahaptra and Gustavsson 2008; Mills and Schleich 2009; Di Maria *et al.* 2010; Willis *et al.* 2011; Mills and Schleich 2012; Michelsen and Madlener 2012; Sardianou and Genoudi 2013).

By and large, there is a positive correlation between income and the likelihood of investing in energy technologies (Long 1993, Mills and Schleich 2010b, Sardianou and Genoudi 2013). Access to credit is also crucial. With the existence of perfect credit markets, poor households should be able to borrow provided their investments are gainful. Normally, persons with higher educational levels and those with children are observed to be more inclined to adopt energy-efficient technologies (Mahaptra and Gustavsson 2008, Mills and Schleich 2009, Mills and Schleich 2012, Michelsen and Madlener 2012, Sardianou and Genoudi 2013). The effect of a person's age on the odds to invest is hazy. While some scholars report that the inclination to adopt energy-efficient or renewable technologies reduces with age (Mahaptra and Gustavsson 2008, Mills and Schleich 2009, Mills and Schleich 2012, Michelsen and Madlener 2012), other findings suggest that middle-aged people are more probable to adopt such technologies than younger generations (Mills and Schleich 2010a, Sardianou and Genoudi 2013).

Technology adoption can also be affected by households' reduced ability or willingness to gather and process information that is crucial to evaluate whether an investment is profitable. Consumers' knowledge of the costs and benefits of different energy solutions, how much energy they utilise in their homes, or the rates of return to expect from energy-efficiency measures is likely to influence the adoption of energy-efficient technologies

(Mills and Schleich 2012). Evidence on households' misperceptions about energy use or savings indicate that there is comparatively little knowledge about the effectiveness of different energy-saving measures. Such inadequate knowledge is likely to influence the likelihood of investing in energy efficiency and renewable sources (Attari *et al.* 2010). Undeniably, when consumers are knowledgeable about the possible energy savings, the propensity to invest in order to conserve energy increases (Scott 1997). Di Maria *et al.* (2010) found that more than 50% of their respondents were not aware of the possible energy savings of compact fluorescent light bulbs compared to the traditional bulbs. In the case of households' reduced ability to process information, authors frequently allude to the concept of 'bounded rationality', implying that customers make use of simple decision-making processes by employing only a part of the existing information for intricate decisions (Simon 1959). Findings on bounded rationality indicated that individuals are more prone to consider features that are easy to comprehend than those that are hard to evaluate, when they engage in investment decisions (Yates and Aronson 1983). Consumers are likely to easily understand the upfront investment cost, whereas assessing the total present worth of energy savings over the life of an investment is a more complicated task, considering the insecurity that borders energy savings and fluxes in energy prices (Jaffe and Stavins 1995, Hassett and Metcalf 1995). This salient effect can prompt households to assign more weight to initial costs than energy savings.

Beliefs, attitudes, and social practices may also motivate individuals to invest over and above pure monetary benefits and costs of an investment. Several studies reported that people with strong environmental preferences are more likely to invest in energy conservation technologies (Olli and Wollebaek 2001, Kollmus and Agyeman 2002, Di Maria *et al.* 2010). Time and again, households' energy use and energy conservation actions are steered by habits, routines, and social practices (Shove 2012). Kahn (2007) underscored the importance of living in environmentalist communities as a driver for environment-friendly behaviour. He showed that individuals living in communities with a higher share of green party members are more likely to use public transport, purchase green vehicles (e.g. hybrid), and consume less gasoline than people in other communities. Olli and Wollebaek (2001) also proposed that social context is important for environmental behaviour, as social participation correlates positively with responsible environmental behaviour. However, although several studies suggested that peoples' attitudes are predictors of energy saving behaviour, often this relationship is weak, explaining only a small part of household energy choices (Viklund 2004, Sjoberg and Engelberg 2005, Di Maria *et al.* 2010).

Energy prices and favourable policy contexts should also affect household technology adoption. Particularly, recent studies highlighted the relevance of urban climate governance, that is, the policies and measures undertaken

by local governments for energy investment to occur (Bulkeley 2010, Bulkeley and Broto 2013).

3. Results and Discussion

3.1. Demographic Characteristics

This section provides characteristics of the beneficiary and non-beneficiary rural women as shown in Table 1. Data on characteristics of the sampled households included educational level of the women, the sex of household heads, household size, age, and the main occupation of respondents and household heads. The majority of the beneficiary women (60%) were literate compared to the non-beneficiary women (34%). Most of the households (95%) were male-headed households. The main occupation of respondents who, in this case, were the rural women was farming. However, the proportion of women who participated in the project and whose main occupation was farming was lower (67) than that of the non-beneficiary women (96%). Actually, 33% of the beneficiary women reported that their main occupation was business. This implies that women who participated in the renewable energy project were involved in income-generating activities. The main occupation for most of the household heads was farming. Here, it was also found that some household heads who participated in the renewable energy project were engaged in businesses (23%). The majority of the participating women (56%) fell in the age range of 21 to 40 years while the majority of non-participating women (65%) were in the age bracket of 41 to 60 years.

Table 1. Household characteristics of the beneficiary and non beneficiary rural women

Characteristics	Beneficiary women n=80 %	Balaka district Non-beneficiary women n=70 %	Total N=150 %
<i>Sex of household head</i>			
Male	96.7	92.6	94.7
Female	03.3	07.4	05.3
<i>Relation of respondent to household head</i>			
Wife	96.7	92.6	94.7
Household head	03.3	07.4	05.3
<i>Literacy levels</i>			
Literate	60.0	34.3	47.15
Illiterate	40.0	65.7	52.85
<i>Main occupation of respondent</i>			
Farming	66.7	96.3	81.5
Business	33.3	03.7	18.5
<i>Main occupation of household head</i>			
Farming	70.7	96.3	83.5
Business	23.3	03.7	13.5
Employment	06.0	00.0	03.0
<i>Age of respondents</i>			
0–20	11.4	08.3	09.8
21–40	56.2	23.5	39.8
41–60	30.2	64.7	47.5
61–80	02.2	03.5	02.9
81 and above	00.0	00.0	00.0

SOURCE: Field data (2014)

3.2. Participation in Sustainable Energy Project Activities

3.2.1. Rural Women's Participation in Sustainable Energy Project Activities

The Sustainable Energy Project introduced a number of activities to the beneficiary groups including adult literacy, afforestation, community forest management, village savings and loans (VSLs) and micro business programmes. The study explored the extent of women's participation in

these activities, and the data are shown in Table 2. The majority of women participated in micro businesses (78%), VSLs (66%), and community-based forest management (63%), and about half of the women had been involved in adult literacy programmes. Findings further showed that almost all women who reported that they belonged to VSL groups participated in micro businesses (98%). Focus group discussions revealed that savings and loans from VSLs were used as capital to start up income-generating activities (IGAs). However, the women said that they could not borrow large sums of money because their savings were small, and this resulted in them investing in small-scale businesses which did not generate sufficient profits. Participating in adult literacy programmes was also mentioned as one of the activities which boosted women’s confidence to join VSLs and conduct micro businesses. Knowledge of numeracy and reading empowered them to participate in VSLs and IGAs. Few women reported that they participated in afforestation because they did not have enough land on which to plant many trees. As such, they practised agro-forestry on the household land, which was mainly used for food production. This shows that small land holding sizes can discourage rural women to plant trees on land as food production outweighs other land uses. Gebreegziabher *et al.* (2010) found that land size, among other factors, determined both the household’s propensity to plant trees and the amount of trees planted in Ethiopia. On the contrary, Mekonnen and Damte (2011) argued that the determinants of the decision to grow trees are not necessarily the same as those involved in deciding the number of trees grown. They found that tenure security increases the likelihood that households will grow trees, but it is not a significant determinant for the number of trees grown while land size influenced the number of trees grown.

Table 2. The proportion of women who participated in Sustainable Energy Project activities

Activity	Beneficiary women (n=80)	
	Participated (%)	Did not participate (%)
Adult literacy	51	49
Afforestation	39	61
Community-based forest management	63	37
Micro businesses	78	22
VSLs	66	34

SOURCE: Field data (2014)

The study further inquired to find out if there were any differences between beneficiary women and non-beneficiary women in their participation in income-generating activities. Even though findings showed that most of the households depended on farming as their main occupation (Table 1), it was clear from the study that households mixed farming with other livelihood options to make ends meet. Table 3 shows the proportion of beneficiary and non-beneficiary women who carried out IGAs. The main categories of the

IGAs that households pursued were on-farm (sale of own agricultural produce), off-farm (trading in agricultural produce) and non-farm IGAs.

Results showed that the proportion of beneficiary women who participated in IGAs was significantly different from the proportion of non-beneficiary women who engaged in IGAs at 1% ($P < 0.001$) for all the three categories of IGAs. These results suggest that beneficiary women were more likely to engage in IGAs than non-beneficiary women. Beneficiary women may have more resources than the non-beneficiary women to engage in IGAs. Focus group discussions revealed that women typically carried out IGAs of one kind or another during the less peak periods of the agricultural calendar. The majority of these IGAs were conventional, minimal capital input, and labour-intensive activities. The IGAs encompassed a typical array including crafts such as basket weaving, baking, traditional beer brewing, and petty trading. The discussions further showed that women shift from one IGA to another based on what is expected to be gainful at a particular time, and that women with demanding and heavy household duties and meagre incomes were less likely to engage in IGAs. In carrying out these IGAs, women reported that they were constrained by lack of time, lack of literacy skills, and poor marketing opportunities. Bieri and Sancar (2009) argued that supporting women in economic enterprises barely incorporated time limitation as a condition which might affect participation rates and inclusion/exclusion. IFAD (1998) found that women with childcare or other heavy domestic obligations such as the care of the sick or elderly selected a less profitable off-farm productive activity in order to combine domestic and productive responsibilities. It reported that the income women generated from their operations might be small, but it played a significant role in meeting family food needs, particularly when harvest was poor. Bieri and Sancar (2009) observed that women's participation in rural employment initiatives and even in the local political arena increased as a result of development projects. However, they argued that women did not get liberated from other time- and energy-consuming responsibilities which were assigned to them according to traditional gender roles even if their bargaining power improved.

Table 3. Rural Women's Participation in IGAs

IGAs	Non-beneficiary women (%)	Beneficiary women (%)	<i>P-Value</i>
On-Farm	39.4	69.5	0.001
Off-Farm	44.6	66.7	0.001
Non-Farm	30.4	76.2	0.001

SOURCE: Field data (2014)

3.2.2. Gendered Participation in IGAs

Data collected on IGAs was disaggregated between men and women to show differences in the proportion of men and women who engaged in IGAs and the type of IGAs that they pursued. The study asked women

respondents to mention the type of IGAs that they carried out. Additionally, the women were asked to state the type of IGAs that their spouses (for married women) and any responsible adult male, in female-headed households, carried out. The study revealed that within the households, men and women alike engaged in the sale of own agricultural produce (71% and 57%, respectively) and the trading of agricultural produce (66% and 54%, respectively), and petty trading (36% and 28%, respectively) with insignificant differences in the proportions. The trading of agricultural produce entailed buying and selling of agricultural produce at the markets, especially after the households had depleted their own agricultural production that they had earmarked for sale. However, significant differences occurred between men and women in their involvement in non-farm IGAs, namely, the sale of charcoal, firewood, crafts, beer, and home-prepared food stuff (Figure 1). Sixty-four per cent of the men and only 5% of the women engaged in charcoal selling (significantly different at 1% ($P < 0.0012$)) while 45% of men compared to 11% of women participated in firewood selling (significantly different at 5% ($P < 0.034$)). Findings further showed that the sale of beer and food stuff from household-based food processing was mainly carried out by women and none of the men. Focus group discussion showed that men usually bought charcoal and firewood from middle-men, who purchased them from the neighbouring district of Mwanza, for sale in Balaka townships and some peripheral towns households. Women, on the other hand, mentioned that they fetched firewood for domestic cooking. Findings, thus, suggest that charcoal and firewood were mainly demanded by men as IGAs that supplied cooking energy to the townships and peripheral township areas while women demanded firewood for domestic cooking rather than for income generation.

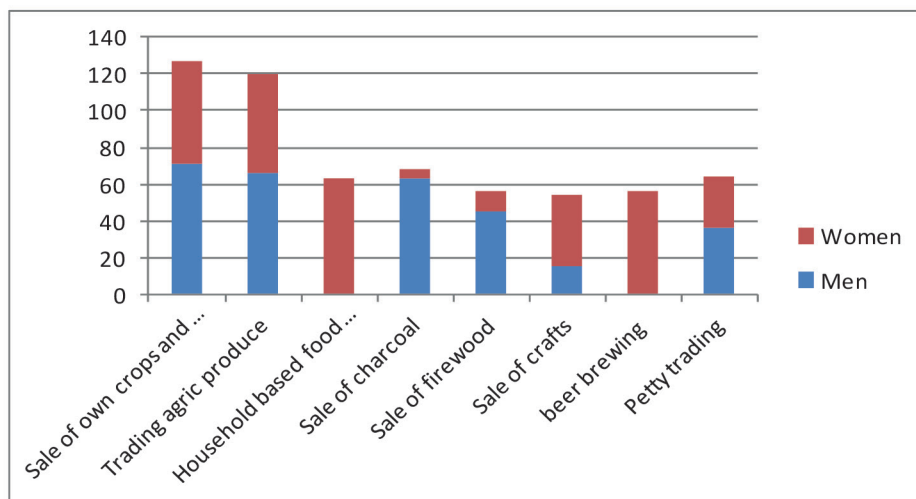


Figure 1. Gendered participation in IGAS

SOURCE: Field data (2014)

3.3. Investment in Clean-Energy-Efficient Cooking Stoves

3.3.1. Rural Women's Investment in Mbaula Energy-Efficient Cooking Stoves

The study sought to identify the sort of energy-efficient cooking technologies that the rural women accessed and used as a low-carbon adaptation strategy in the area. Focus group discussions showed that an energy-efficient stove called *Mbaula* cooking stove was the most important technology to women. Out of the 150 rural women who participated in this study, 44% invested in *Mbaula* cooking stove (Figure 2). Findings further showed that among the beneficiary women, 58% invested in *Mbaula* cooking stove compared to 29% among non-beneficiary women (significant at 5% ($P < 0.002$)) (Figure 3). During focus group discussions, those women who did not invest in the cooking stoves mentioned that they could not afford to buy cooking stoves because of financial constraints. Those women who bought the cooking stoves reported that *Mbaula* cooking stove uses less firewood compared to the traditional 3-stone cooking place. A weighted scoring method, which women conducted during focus group discussions, revealed the benefits of *Mbaula* cooking stove in that order: (1) it uses smaller amounts of firewood. This means reducing their time burden for collecting firewood used in cooking and heating; (2) it improves health and wellbeing of household members by increasing the frequency of cooking with reduced firewood fumes, hence improving nutrition; (3) it enables women to support livelihood activities as they have extra time to engage in economic enterprises and capacity building through participation in adult literacy programmes and other

trainings. The women reported that being able to read and write enabled them to take up leadership positions in the community. This may help to explain why the majority (60%) of the beneficiary women were literate compared to the non-beneficiary women (34%) (Table 1), and why more beneficiary women participated in IGAs (Table 3). Econometric evidence in the logit regression model presented later gives possible explanations for the variations in the outcome of investing in *Mbaula* cooking stoves. The study, thus, argues that limited access to energy-efficient cooking stoves by rural women further impoverishes them and increases their workload in the home since women participate less in economic activities with reduced time to earn income and less means to productively use the money they earn. This, in turn, has negative impacts on the country’s economy.

Literature shows that time spent in fuel collection in fuel-scarce areas can range from 1 hour to 5 hours per household per day. The documented implications of this include reduced water heating and washing, and decreased time and fuel used for cooking, at times even decreased female time devoted to agricultural work and food production and negative impacts on nutritional and health status (Cecelski 1993, Brouwer *et al.* 1989, Kumar and Hotchkiss 1988). Health and safety are major concerns of women in their use of biomass fuels. Smoke reduction and improved safety for children are often the two most important reasons cited by women for adopting improved stoves and fuels (Celceski 2000).

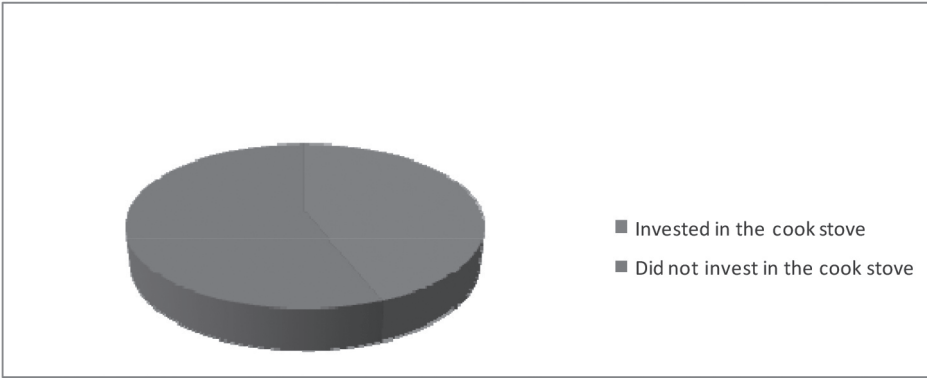


Figure 2. The Proportion of Rural Women Who invested in *Mbaula* cooking stove.
SOURCE: Field data (2014)

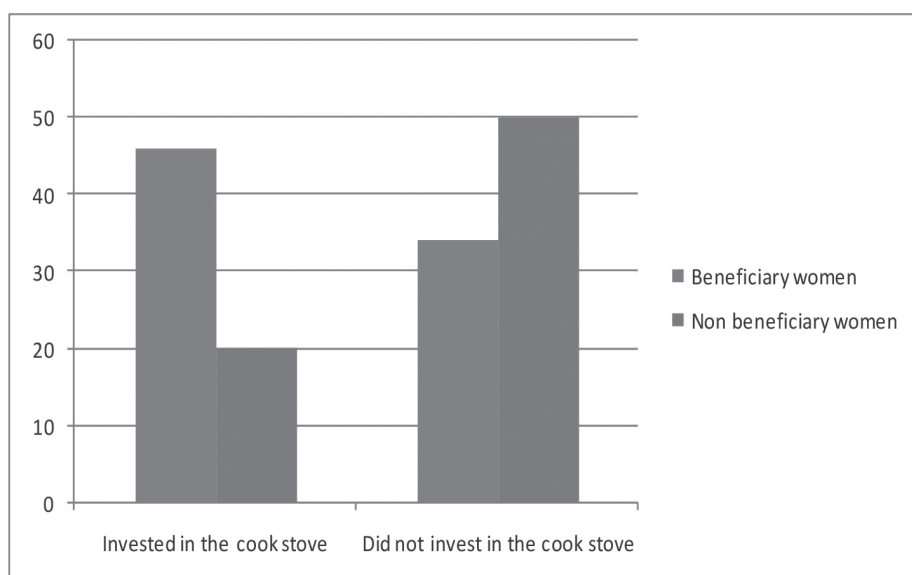


Figure 3. The proportion of beneficiary and non-beneficiary rural women who invested in *Mbawla* cooking stove.

3.3.2 Determinants of Investing in Mbawla Cooking Stoves

The study was further interested in exploring the factors which affected the rural women to invest in *Mbawla* cooking stoves as a low-carbon adaptation strategy. In order to determine the factors which influenced the rural women to invest in *Mbawla* cooking stoves and their degree of influence to invest in the cooking stove, a regression analysis was carried out using the logit model. The logit analysis was chosen because the dependent variable, investment, in *Mbawla* cooking stove is dichotomous in nature. This is to say, the dependent variable was a categorical variable of only two responses, 'yes' and 'no'. The regression was run in SPSS and the results are presented in Table 5.

3.3.3. Variables in the Mbawla Cooking Stove Investment Model

Table 4 presents descriptive statistics of the variables in the *Mbawla cooking stove investment model*. Most of the households in the sample were male-headed households (95%). Seventy-four per cent of the women perceived that *Mbawla* cooking stove was expensive. The average age of the women was 41 years old. Eighty-two per cent of the women were knowledgeable about the amount of firewood which was saved by using the efficient cooking stoves. In terms of human capital, about 47% of the women were literate. Sixty-six per cent of the households participated in NGOs which were addressing environmental concerns in their community, and 63 per cent of the women belonged to village savings and loans (VSLs). The average household size was seven.

Table 4. Descriptive statistics of variables in the *Mbaula* cook stove use model

Variable	Mean	Std. Dev	Min	Max
Sex of household head (SEX)	0.947	0.3452	0	1
Dummy = 1 if household head is male				
Perception of price of cooking stove (PRICE)	0.7428	0.4379	0	1
Dummy = 1 if cost is high				
Age of respondent (AGE)				
Dummy = 1 if respondent was 50 years old or less	40.82	12.72	20	78
Knowledge (KNOW)	0.8150	0.4457	0	1
Dummy = 1 if knowledgeable about fuel saved				
Literacy levels of the respondent (LIT)	0.4715	0.4281	0	1
Dummy = 1 if respondent was literate				
Household conservation practice (CONSERVE)	0.6630	0.3030	0	1
Dummy =1 if household practises natural resource conservation				
Income-generating activity (IGA)	0.6348	0.2473	0	1
Dummy = 1 if respondent was engaged in any IGA				
Membership to VSLs (VSLs)	0.6341	0.4826	0	1
Dummy = 1 if respondent belonged to VSL				
Household size number (HHSIZE)	6.7609	9.7296	1	15

SOURCE: Field data (2014)

3.3.4. Interpretation of the Logit Regression Analysis

Results in Table 5 present econometric evidence on the determinants of investing in *Mbaula* cooking stove as a low-carbon adaptation strategy among the rural women. It shows logistic regression estimates for investment in *Mbaula* cooking stove model. The table illustrates that rural women's investment in *Mbaula* cooking stove was related to the sex of the household head, women's price perception of the *Mbaula* cooking stove, the age of the women, women's knowledge regarding fuel saved by using *Mbaula* cooking stove, literacy level of the women, household's participation in NGOs addressing environmental concerns, women's participation in IGAs, women's membership in VSL, and household size. The Nagelkerke R-square shows that the variables in the model are valuable in predicting investment in *Mbaula* cooking stove by rural women. The explanatory power of the model is sensible with an R-squared of 68 per cent. The Homer and Lemeshow test result indicates that the observed

investment in *Mbaula* cooking stove is not significantly different from the one predicted by the model. Here the P-value is insignificant ($0.776 > 0.05$), which actually confirms that the fit of the model is good and the expected linear relationship can be supported.

The estimated coefficient for sex was positive and significantly different from zero at $P < 0.05$. The sex of household heads was positively related to investment in *Mbaula* cooking stove by rural women. In this case, rural women who were married and in male-headed households were three and a half times more likely to invest in *Mbaula* cooking stove than rural women who were female household heads. Most of the women were married and belonged to male-headed households (95%) compared to female household heads (5%) (Table 5). One explanation supports the investment in *Mbaula* cooking stove by married women in male-headed household. Rural women are among the poorest and most vulnerable people who experience challenges in accessing technologies because of the capital costs associated with them (e.g., buying a cooking stove). However, in this study it was found that the majority of the male household heads were entrepreneurial, and the income obtained from the small businesses such as the sale of charcoal and firewood may have allowed the households to purchase a *Mbaula* cooking stove.

Table 5. Logit regression results for determinants of investment in *Mbaula* cook stove

Variable	Coefficient	S.E.	Odds Ratio Exp (B)	T-statistic
SEX	1.264	0.496	3.538	2.548**
PRICE	0.090	0.103	0.914	0.873*
AGE	0.019	0.010	1.019	1.900*
CONSERVE	2.844	0.661	17.188	4.302***
KNOW	0.127	0.396	1.135	0.320
IGA	0.714	0.491	2.042	1.454
LIT	0.711	0.551	0.491	0.1.290
HHSIZE	0.305	0.289	1.357	1.055**
VSL	0.341	0.356	1.406	0.958
Nagelkerke Rsq = 0.68				
Model significance = 0.013				

SOURCE: Field data (2014)

Hosmer and Lemeshow Test, Chi-square = 4.862 ($p < 0.776$)

Note: *** shows significance at $p < 0.01$; ** significance at $p < 0.05$; and *shows significance at $p < 0.1$

The coefficient for the price of *Mbaula* cooking stove was positive and significant at $P < 0.01$. This implies that women's perception about the price of the energy-efficient cooking stove reduced the probability of women to invest in them. The higher the cost, the more likely that rural women would

not purchase them. Focus group discussions attested to this finding by revealing that women who were not using *Mbaula* cooking stove could not afford to buy them. A study that determined the choice for investing in compact fluorescent lighting (CFL) bulbs showed that from a sample of 376 households, 38 per cent did not buy the CFL bulbs due to the high cost (Uitdenbogerd 2007). Some authors argued that ownership of CFLs was higher in households with higher levels of income and education (Ürge-Vorsatz and Hauff 2001).

The coefficient for age was positive and significant at $P = 0.1$. The age of the woman appeared to be a relevant variable for investing in *Mbaula* cooking stove. This means that the age of women was positively associated with investing in *Mbaula* cooking stove, implying that the younger the woman, the more likely she was to invest in the cooking stove. In this study, women aged 50 years or less were more likely to use *Mbaula* cooking stove than those above 50 years of age. Ameli and Brandt (2015) reported that investing in light bulbs, heat thermostats, thermal insulation, and energy-efficient windows depended positively on age, while the probability to choose heat pumps decreased with age. Previous studies verified that the likelihood of investing reduced with age for novel heating systems, such as heat pumps (Mahaptra and Gustavsson 2008; Michelsen and Madlener 2012). On the other hand, it improved with age for energy-efficient light bulbs (Mills and Schleich 2012; Mills and Schleich 2014). According to Mills and Schleich (2009), age was not a relevant variable for investment in solar panels. Sardanou and Genoudi (2013) found that middle-aged people were more likely to invest in renewable energy sources than younger people, and Willis *et al.* (2011) suggested that families with members older than 65 years were less likely to adopt solar technologies compared to the rest of the population. By and large, the effect of age on the likelihood of investing in clean energy technologies appears to be technology-specific and perhaps sometimes driven by age brackets and, therefore, not conclusive.

There is compelling proof that households which often conduct low-cost energy conservation actions are also more likely to spend their income to preserve energy or use renewable sources. The coefficient for CONSERVE was positive and highly significant at $P < 0.01$. Regression results suggested that the role of social context is important for investment decisions. Households which participated in NGOs which attended to environmental issues were more likely to invest in *Mbaula* efficient cooking stove than households which did not participate in NGOs whose focus was on environmental concerns. Ameli and Brandt (2015) found that such social participation correlated positively with technology adoption for energy-efficient appliances, light bulbs, heat thermostats, thermal insulation and energy-efficient windows. They argued that when households engaged in environmental associations, they were even more likely to invest than others who were involved in non-environmental NGOs. Studies conducted

by Olli and Wollebaek (2001) and Khan (2007) also found that social perspective was a significant forecaster of environmental conduct.

Household size was positively related to the likelihood of investing in *Mbaula* cooking stove. This implies that the inclination to invest in the energy-efficient cooking stove increased as the number of household members went up. These results agree with prior studies which also found that the tendency to adopt solar technologies and light bulbs increased with family size and children (Mills and Schleich 2009; Mills and Schleich 2012). Mills and Schleich (2010a) and Mills and Schleich (2012) suggested that a positive association between family size and technology adoption applied also for energy-efficient appliances.

Knowledge about the fuel quantity which was saved by using *Mbaula* cooking stove, literacy levels, IGAs, and VSLs were all positive but not significant. These variables did not seem to play an important role for investment decisions in *Mbaula* cooking stove.

4. Conclusion and Recommendations

This study set out to investigate whether rural women's participation in a sustainable energy project in southern Malawi enabled them to engage in activities that improved their livelihoods and the factors that influenced the rural women to invest in clean-energy-efficient cooking stoves as a low-carbon adaptation strategy.

The study determined that beneficiary women participated in various sustainable energy project activities, namely, micro businesses, VSLs, afforestation, community-based forest management, and adult literacy programmes. Their participation in afforestation activities was minimal because of land shortages. The study further found that there were significant differences between beneficiary women and non-beneficiary women in their participation in the three categories of income-generating activities, namely: on-farm, off-farm, and non-farm IGAs. Beneficiary women engaged significantly in all the three forms of IGA compared to non-beneficiary women. This suggests that development projects boosted the capacity of rural women to engage in economic activities that improved their livelihoods. However, in carrying out the IGAs, they were constrained by time, illiteracy, and poor marketing opportunities. It can, therefore, be concluded that rural women's participation in sustainable energy project activities empowered them to engage in income-generating activities despite the challenges involved.

The study endeavoured to investigate differences in the types of IGA that women and men carried out in the area. The study determined that within the households, men and women alike engaged in the sale of agricultural produce from their own harvests, the trading of purchased agricultural produce, and petty trading. However, significant differences were observed between men and women in their involvement in non-farm IGAs, namely,

the sale of charcoal and firewood. Men traded in charcoal and firewood while women searched firewood for domestic cooking. It is, therefore, concluded that charcoal and firewood were mainly demanded by men as IGAs that supplied cooking energy to the townships and peripheral township areas while women demanded firewood for domestic cooking rather than for income generation. Addressing these different requirements for biomass, thus, involves different solutions which have implications on issues of land use and management, access to resources, community forest management, establishment of woodlots for afforestation, and land access and ownership, especially for women.

The study also aimed at providing clear evidence regarding the determinants of investment in *Mbaula* clean-energy-efficient cooking stove as a low-carbon adaptation strategy. Results provided clear evidence showing that the sex of the household head was significant and positively related to women's propensity to invest in *Mbaula* cooking stove. Rural women who were married and in male-headed households were more likely to invest in *Mbaula* cooking stove than rural women who were female household heads.

The coefficient for the price of *Mbaula* cooking stove was positive and significant, implying that rural women's perception about the price of the energy-efficient cooking stove reduced the probability of women investing in them. The higher the cost, the more unlikely that rural women would purchase them. Moreover, the coefficient for age was positive and significant, meaning that the younger the woman was, the more likely she was to invest in the cooking stove. In this study, women aged 50 years or less were more likely to use *Mbaula* cooking stove than those above 50 years of age. Investment in *Mbaula* cooking stove was also influenced by households' attitudes and beliefs, as households who were in an environmental group or who were ready to engage in low-cost energy conservation practices were also more likely to invest in energy efficiency or renewable sources as a low-carbon adaptation strategy. Household size was positively related to the likelihood of investing in *Mbaula* cooking stove. This implies that the inclination to invest in the energy-efficient cooking stove increased as the household size increased. All in all, this study determined that the sex of the household head, the price of the cooking stove, the age of the women, households' attitudes and beliefs about the environment and household size influenced rural women's investment in *Mbaula* cooking stove as a low-carbon adaptation strategy.

The paper, thus, advances the following key messages: Firstly, energy supply is fundamental to the attainment of educational, health, and nutritional outcomes. It should be integrated into policies, strategies, and interventions of livelihood programmes; it should also be part of literacy, forestry, and income generation programmes; secondly, the role of firewood and charcoal in the livelihood strategies of women and men should be distinguished. Charcoal is mainly demanded by men as an

income-earning activity that supplies cooking energy to the urban and peripheral areas while women demand firewood for domestic cooking. Addressing these different requirements for biomass should involve different solutions which have implications on issues of land use and management, access to resources, community forest management, establishment of woodlots, land ownership, and provision of wood in the short-run until woodlots are mature; finally, satisfying women's demand for energy requires encouraging fuel-efficient stoves. Women should be incentivised to promote their uptake of renewable energy technologies as a low-carbon adaptation strategy. Furthermore, there is a need to scrutinise household resource control and household structures when determining the capacity to invest in such low-carbon adaptation strategies. Since women possess little control over household resources, particularly land and income, the technologies should essentially signify that they benefit both men and women.

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CHAPTER SIX

Environmental and Economic Feasibility of Bioethanol Systems: Towards Climate Compatible Development

Riad Sultan

Abstract

As a renewable energy with significant economic and climate benefits, bioethanol offers a vital opportunity for a climate compatible development strategy. Two popular indicators for the assessment of a bioethanol system are the net renewable energy balance and the CO₂ emission avoided. While a positive net renewable energy balance and an amount of avoided CO₂ are the necessary conditions for bioethanol development, they are not the sufficient conditions to make it climate compatible. By defining the environmental and economic feasibility sets of bioethanol systems, the chapter develops a decision support framework to analyse the necessary and sufficient conditions under which bioethanol can be classified as a climate compatible development. The economic feasibility compares the life-cycle cost of bioethanol with the price of an equivalent energy from conventional source while the environmental feasibility compares the climate and other environmental benefits from CO₂ avoided with the social costs of bioethanol. The study concludes that the environmental feasibility condition of bioethanol system in relation to global climate benefits may not necessarily be consistent with the economic feasibility set characterising local benefits. In the case that bioethanol is not economically feasible, the global climate benefits from CO₂ avoided must be sufficiently high to justify bioethanol development and this is obtained when the social cost of CO₂ exceeds a threshold. The decision support framework is applied to a sugar-based bioethanol system in Mauritius. By collecting primary data on the bioethanol system, the study concludes that it is not economically feasible to produce bioethanol. In this respect, the environmental benefits must be high to make it a sustainable energy. The study eventually discusses the national and international policies which might be necessary to make bioethanol development climate compatible.

Keywords: Bioethanol, CO₂ emission avoided, energy balance, social costs, sustainable energy systems.

1. Introduction

In recent years, there has been an upsurge of interest among scholars to search for climate compatible development (CCD) that results to a low-carbon economy with higher resilience, and promotes economic development (Mitchell and Maxwell 2010). According to the Climate and

Development Knowledge Network, CCD is defined as the development that minimises the harm caused by climate impacts, while maximising the many human development opportunities presented by a low emission, more resilient future (Mitchell and Maxwell 2010). Indeed, CCD has emerged as a new concept to bridge the gap between climate change policies and the creation of employment and wealth (Stringer *et al.* 2014). A CCD pathway may highlight several dimensions. Sustainable development is at the core of the pathway given that climate change and development are intricately linked. The second major dimension is lessening the vulnerability caused by climate change and at the same time encouraging greenhouse gas emissions that are lower than business-as-usual practice. CCD also conforms to the green economy pathway — one that results in improved human well-being and social equity while significantly reducing environmental risks and ecological scarcities.

Bioethanol in this respect offers a vital opportunity for a CCD strategy. It is classified as a renewable energy with significant economic, energy security and climate benefits. The blend of bioethanol with gasoline is expected to reduce the dependency on fossil fuels and according to the International Energy Agency (IEA), bioethanol has the potential to contribute up to 10% of world gasoline use by 2025 and 30% by 2050 (Amigun, Sigamoney, von Blottnitz 2008). Bioethanol enrichment has a major climate benefit by curbing greenhouse gases (GHGs), especially CO₂. According to Martines-Filho, Burnquist and Vian (2006), the blend of ethanol with gasoline at the rate of 10% (E10) may reduce GHGs by 12–19% and carbon monoxide by 30% compared to gasoline. Since the energy from bioethanol is generated from organic matter, that is, sugar cane, bioethanol is considered as a carbon-neutral energy. This is because the same amount of CO₂ is emitted when using bioethanol as was absorbed during the feedstock growth (Schubert and Blasch 2010). Its production is therefore ‘sustainable’ by the closure of the carbon cycle (Niven 2005). Bioethanol is therefore crucial for mitigating global climate change.

There are other advantages when using bioethanol. For instance, it reduces the need to use foreign exchange to purchase gasoline and this in turn may bring about multiple positive macroeconomic effects. It can also provide a new source of income to planters in the sugar industry who are struggling with competitive world market prices (Thomas and Kwong 2001). Developing countries including Zimbabwe, Kenya, Egypt, Zaire, Zambia, Sudan, Swaziland, and Mauritius could replace gasoline with ethanol using primarily sugar as feedstock (Thomas and Kwong 2001) and re-engineer their sugar sector accordingly.

However, the overall performance of a bioethanol system in reducing non-renewable energy and GHGs depends on the level of fossil fuel consumed and carbon dioxide (CO₂) and other GHGs emitted through its entire lifecycle, from the preparation of feedstock, to the conversion phase and finally to consumption (Botha and Blottnitz 2006; Goldemberg, Coelho,

and Guardabassi 2008). The cultivation and manufacture of feedstock can also lead to the generation of environmental externalities, such as the potential impacts on subsurface soils and groundwater (Niven 2005) as well as peculiar externalities by shifting supply and demand in input and output markets (Jaeger and Engelkraut 2011). Land use changes may also release CO₂ when the cultivation of feedstock decreases carbon sequestration capacity.

An important indicator of bioethanol system performance is the net renewable energy balance which refers to the difference between the energy gain from a unit of bioethanol consumed (usually measured by its energy content) and the non-renewable energy used in its production pathway (Prakash, Henham and Bhat 1998; Henke, Klepper and Schmitz. 2005; Nguyen, Shabbir and Gheewala 2008). Recently, a number of studies have estimated the amount of CO₂ emission avoided when a unit of bioethanol is used. CO₂ emission avoided is defined as the amount of carbon displaced when replacing fossil fuel by bioethanol, especially in the transport sector (Macedo, Seabra and Silva 2008; Silalertruksa and Gheewala 2009). The NREB and the CO₂ emission avoided usually determine the sustainability of a bioethanol system and are used to assess its feasibility. Indeed, a positive NREB and the amount of displaced CO₂ are the necessary conditions to make bioethanol a potential substitute for fossil energy to curb climate change. However, these two indicators are scarcely sufficient.

An important efficiency criterion in economic development is to examine the cheapest pathway or the least-cost combination to achieve a particular outcome. In this respect, it is important to highlight the production and processing costs associated with the manufacture of feedstock to the conversion phase of bioethanol. Feedstock price, investment cost, labour cost, among others, are determined by the location, design and management of the facility and vary from one region to another (Yu and Tao 2009). The critical question is whether bioethanol helps to reduce non-renewable energy and CO₂ emission at a reasonable cost and whether it offers a cost-effective means to achieve the goal of a low-carbon economy (Duer and Christensen 2010; Le *et al.* 2013). It is observed that the high costs of producing bioethanol in certain countries often require subsidies from the government (Ajanovic and Haas 2010; Sims *et al.* 2010; Jaeger and Engelkraut 2011). From an economic point of view, the cost of producing bioethanol which brings about an energy gain (as measured by the NREB) must be compared to the cost of acquiring the same energy from an alternative conventional fuel. Or rather, the fuel saving option has a 'price'. This is an important milestone in a CCD strategy.

When the price of gasoline is relatively more competitive, it questions the economic feasibility of producing bioethanol. There is indeed substantial ground to conclude that conventional fuel, such as gasoline has a cost advantage over bioethanol. At least two reasons are provided by Jaeger and

Egelkraut (2011: 1) first, the energy content as measured by the heating value of bioethanol (in megajoules) is less than gasoline for a corresponding denominator, implying that a relatively higher level of bioethanol is needed to replace an equivalent level of conventional fuel; and second, fossil fuel consumed in the production process reduces the energy gain from bioethanol. The life-cycle cost (LCC) of producing bioethanol consequently competes with the price of traditional non-renewable energy as an alternative option and this defines the economic feasible set.

In fact, the story of bioethanol is scarcely completed if only the energy gain and the associated costs are considered. There are also the carbon emissions avoided as well as environmental externalities which are not often accounted in bioethanol assessment (Le *et al.* 2013). Therefore, an environmental feasibility set can be defined over the environmental costs and benefits including the reduction of CO₂ and curbing climate change — an important dimension for climate compatible development.

What constitutes the climate compatible decision set for bioethanol? Evidently, a possible answer is when it is feasible from both perspectives — economic and environmental. In case it is not economically feasible, then the carbon emission avoided and other benefits must be sufficiently high to offset its uncompetitive economic characteristics. The marginal social cost of CO₂ which reflects the climate benefits of a reduction in CO₂, and the LCC are therefore two variables which influence the climate compatible investment.

This study conceptualises the economic feasibility and environmental feasibility set of bioethanol production system to analyse the necessary and sufficient conditions to make it a climate compatible investment. It also adds to the literature on sustainability framework and decision support tools to analyse the performance of bioethanol systems as developed by Afgan, Carvalho and Hovanov (2000), Elghali *et al.* (2007), Zhou (2007) and Pirimenis *et al.* (2011). The framework uses NREB, the CO₂ emission avoided, the life-cycle cost assessment and social cost of carbon emission to search for a climate compatible combination and is eventually applied to the bioethanol system in Mauritius. The remainder of the chapter is structured as follows. Section 2 provides the conceptual framework, with a definition of key variables and decomposes the analysis into the economic feasibility condition and environmental feasibility condition. The framework is applied to a bioethanol production system in the case of Mauritius and results are provided in section 3. Section 4 presents the conclusion and policy implications.

2. Conceptual Framework

A necessary condition for bioethanol to be a CCD is a positive NREB. The NREB is an indicator which measures the energy gain when one unit of

bioethanol is consumed. It is calculated by the difference between the energy content of bioethanol and the energy used in its production processes. If $y_{ethanol}$ denotes the energy content of bioethanol per litre and y_{fossil} is the fossil fuel energy per litre consumed in the production processes, the NREB per litre of bioethanol is therefore defined as follows:

$$NREB = y_{ethanol} - y_{fossil} \quad \dots\dots\dots(1)$$

A necessary condition for bioethanol to be economically feasible is

$$NREB > 0 \quad \dots\dots\dots N1$$

Condition N1 determines the amount of fossil fuel saved when bioethanol replaces fossil fuel. Emphasis is laid on the direct effects of the reduction in fossil fuels. Economy-wide effects are not accounted in this framework yet, but can be easily extended to do so. Thus, if the price of one litre of gasoline is $P_{gasoline}$ and its energy content is $y_{gasoline}$, the marginal private benefit (MPB) from the use of bioethanol is calculated as follows:

$$MPB = \frac{NREB}{y_{gasoline}} P_{gasoline} \quad \dots\dots\dots (2)$$

Equation (2) represents the amount of energy saving per litre of ethanol in monetary terms by evaluating it in terms of its best foregone option.

The LCC of bioethanol refers to the costs from the manufacturing of feedstock to the conversion of ethanol and distribution to consumers (Zhou 2007; Yu and Tao 2009). It is commonly used as an economic indicator for assessing the economic sustainability of biofuels.

Based on the marginal private benefit and LCC, we define the economic feasibility sets of bioethanol as follows:

$$MPB \geq LCC \quad \text{Bioethanol is economically feasible} \quad \dots\dots(3)$$

$$\text{That is } \frac{NREB}{y_{gasoline}} P_{gasoline} \geq LCC \quad \dots\dots\dots(3a)$$

Equation (3a) compares the cost of producing bioethanol with the cost of acquiring conventional energy by adjusting for the energy content (the heating value) of the two types of fuels. The first component from the left hand side gives the price at which the current system may supply an equivalent energy as provided by bioethanol. For equation (3a) to hold, condition (N1) is necessary.

When bioethanol replaces gasoline, it also displaces and reduces an amount of CO₂ emission. However, since consuming a given level of bioethanol does not eliminate an equivalent amount of gasoline as explained earlier, the reduction in CO₂ is relatively lower. A litre of bioethanol eventually

reduces gasoline to the order of $\frac{y_{ethanol}}{y_{gasoline}}$ and hence, if the level of CO₂

when one litre of gasoline is combusted is denoted $x_{gasoline}$, the reduction

of CO₂ is $(\frac{y_{ethanol}}{y_{gasoline}})(x_{gasoline})$ (4)

As mentioned in the introduction, bioethanol is considered as a carbon-neutral energy source because CO₂ emitted during its combustion was previously absorbed from the atmosphere by the plants used as feedstock during the growing phase (Niven 2005; Schubert and Blasch 2010; Jaeger and Egelkraut 2011). However, a closer scrutiny of the production pathway for bioethanol shows that CO₂ is emitted during the different stages of production. Assume that this is denoted by $x_{bioethanol}$ per litre of bioethanol, the avoided CO₂, is calculated as:

$$x_{avoided} = (\frac{y_{ethanol}}{y_{gasoline}})(x_{gasoline}) - x_{bioethanol} \quad \text{..... (5)}$$

CO₂ emission avoided is a global benefit when using bioethanol instead of gasoline since it positively contributes to climate change mitigation. The benefit can be monetised using the concept of marginal social cost of carbon defined as the cost which one additional unit of carbon released, in the form of CO₂, into the atmosphere will cause the society as a whole (see Mandell 2011). If the marginal social cost of CO₂ is C_{co2} , the marginal climate benefits (MCB) of one litre of ethanol can be denoted by:

$$MCB = C_{CO2}(x_{avoided}) \quad \text{..... (6)}$$

For $MCB \geq 0$, a positive figure of CO₂ avoided is necessary such that

$$x_{avoided} \geq 0 \quad \text{.....}$$

N2

We therefore have a second necessary condition for bioethanol to make it CCD, given by N2.

At this stage, it is essential to distinguish between costs as defined earlier through the LCC and externalities which may take different forms. Thus, pecuniary externalities exist when supply and demand conditions in input and output markets change, leading to market adjustments which affect welfare (Jaeger and Egelkraut 2011). For example, the rise of food prices due to land being devoted to bioethanol causes food insecurity among the poor or the rise in land prices following a rise in demand for cultivated land. This may lead to an expansion of agricultural production in other areas not previously under cultivation. There are also externalities attributed to land changes and environmental degradation. The indirect market effects may release significant quantities of carbon that have accumulated over long periods in soil and vegetation. Land use changes may release CO₂ because of deforestation.

The external cost per litre ($Z_{externalities}$) as defined here does not include CO₂ emitted from the production of bioethanol because this component is already accounted in the CO₂ emission avoided. We can therefore define an environmentally feasible condition for bioethanol such that:

$$MCB \geq Z_{externalities} \quad \text{Bioethanol is environmentally feasible.....(7)}$$

That is,

$$C_{CO_2}(x_{avoided}) \geq Z_{externalities} \quad \text{..... (8)}$$

Equation (8) compares the marginal benefits of bioethanol in relation to curbing climate change with the marginal-costs-associated negative externalities. Equation (8), together with (3a), provides two sufficient conditions to make bioethanol a development which is compatible with climate change. However, it does not imply that when conditions N1 and N2 hold, the economic feasibility condition (3a) and environmental feasibility condition (8) will also hold. Nor does it imply that condition (3a) will also encourage condition (8).

To deepen our understanding on these CCD conditions for bioethanol, the economic feasibility and environmental feasibility are restated in terms of the price of conventional fuel and the marginal cost of CO₂. Thus, conditions (3a) and (8) can be rewritten in terms of price of gasoline and marginal cost of CO₂ such that the economic and environmental feasibility conditions can be restated respectively as follows:

$$\frac{NERB}{y_{gasoline}} P_{gasoline} \geq LCC \quad \text{..... A1}$$

$$C_{CO_2}(x_{avoided}) \geq Z_{externalities} \quad \text{.....A2}$$

Even if N1 and N2 are necessary conditions as shown above, they are not sufficient. When conditions N1 and N2 hold, the bioethanol system may not satisfy conditions A1 and A2. In this case, the condition which is sufficient to justify bioethanol investment warrants investigation.

A CCD for bioethanol may be restated in terms of marginal social benefit and marginal social cost. Thus, we define the marginal social benefit (MSB) as the sum of the marginal private benefit (MPB) (eq. (2)) and the marginal climate benefit (MCB) (eq.(6)) and, therefore, is represented as follows:

$$MSB = MCB + MPB \quad \dots\dots\dots (9)$$

$$= C_{CO_2}(x_{avoided}) + \left(\frac{NERB}{y_{gasoline}}\right)(P_{gasoline}) \quad \dots\dots\dots (9a)$$

The marginal social cost of producing one litre of ethanol is MSC :

$$MSC = LCC + Z_{externalities} \quad \dots\dots\dots (10)$$

The sufficient condition that makes bioethanol a feasible solution is given as follows:

$$MSB \geq MSC \quad \dots\dots\dots (11)$$

i.e.

$$C_{CO_2}(x_{avoided}) + \left(\frac{NERB}{y_{gasoline}}\right)(P_{gasoline}) \geq LCC + Z_{externalities} \quad \dots\dots (12)$$

Rearranging

$$C_{CO_2}(x_{avoided}) \geq Z_{externalities} - \left[\left(\frac{NERB}{y_{gasoline}}\right)(P_{gasoline} - LCC)\right] \quad (12a)$$

The left hand side of equation 12a is the climate benefit of using one litre of bioethanol. On the right hand side, the first component is the net externalities (positive less negative externalities) associated with the production of a litre of ethanol and the second component is the economic feasibility set as defined previously.

Equation (12a) can be manipulated to work out a benefit-cost equation in terms of the marginal social cost of 1kg of CO_2 . That is,

$$C_{CO_2} \geq \frac{Z_{externalities}}{x_{avoided}} - \left(\frac{1}{x_{avoided}}\right) \left[\frac{NERB}{y_{gasoline}}\right](P_{gasoline}) - LCC \quad \dots\dots (12b)$$

Equation 12b is eventually used to define a set of points which demarcate a CCD feasible from the CCD non-feasible sets of points, as shown in Figure

1. Thus, we define a set PP such that

$$C_{CO_2} = \left(\frac{1}{x_{avoided}}\right)(Z_{externalities}) - \left(\frac{NERB}{y_{gasoline}}\right)(P_{gasoline}) + \left(\frac{1}{x_{avoided}}\right)LCC \quad \dots\dots\dots (13)$$

Line PP is drawn to reflect equation (13), that is the exact marginal social cost of CO₂ (climate benefits) which would just offset any net negative externalities and any gap in the private benefit and cost of producing bioethanol.

To be able to distinguish between the economic feasibility and the environmental feasibility, we define MM such that

$$LCC' = \frac{(NERB)(P_{gasoline})}{y_{gasoline}}. \text{ } LCC' \text{ presents the maximum cost which}$$

will make bioethanol just indifferent to the cost of an equivalent energy from conventional sources. If the LCC of bioethanol lies to left of MM, it will mean that bioethanol is not economically feasible, that is,

$$LCC > \frac{(NERB)(P_{gasoline})}{y_{gasoline}}. \text{ } \text{The reasoning is that the cost of producing}$$

bioethanol is sufficiently high or the price of the alternative fuel is relatively low such that the energy gain and fossil fuel saving from bioethanol is not cost-effective. Points to the right of MM show all economically feasible sets. The price of gasoline is high enough relative to the cost of producing bioethanol and this makes bioethanol an economically viable investment. Indeed, this is the case in many African countries where the high transportation cost of a wholesale gasoline makes bioethanol considerably cheaper (Thomas and Kwong 2001).

The interaction between the economic feasibility and environmental feasibility can be illustrated in Figure 1. Four quadrants are defined. In quadrant B, for any level of LCC, the marginal social cost of carbon-dioxide emission is high enough to derive climate benefits, making bioethanol climate compatible development. In quadrant A, the marginal social cost of CO₂ is above line PP, implying that there is indeed high climate benefit, even if it is not economically feasible to produce bioethanol.

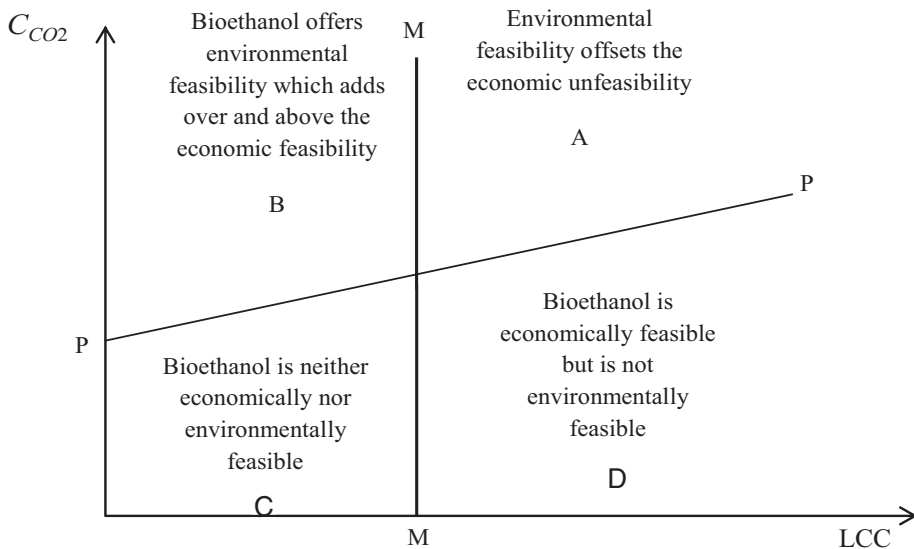


Figure 1. Economic and Environmental Feasibility Sets for Bioethanol Production System

SOURCE: Author

Points to the left of MM and below PP (quadrant C) show that bioethanol is neither economically nor environmentally feasible. In quadrant D, producing bioethanol reflects a competitive LCC vis-à-vis the price of conventional fuel but still the negative externalities are high relative to climate benefits to make it environmentally feasible.

To illustrate the decision support framework to a bioethanol system, the characteristics of a production unit of bioethanol in the Republic of Mauritius is analysed. This is the subject matter of the next sections.

3. An Application of the Decision Support to the Mauritian Bioethanol System

Mauritius is an island of approximately 1860 km² with a population of 1.24 million (Statistics Mauritius 2014). At the time of its independence in 1968, the island was based mainly on sugar cane cultivation. It eventually made sugar exports as the backbone of the economy, helped significantly by the ACP-EU Sugar Protocol where Mauritius benefitted a quota for sugar exportation at a guaranteed price to the EU market (Wellisz and Saw 1994). Sugar exports contributed extensively to the Mauritian economic performance during the last decades or so, creating employment and earning foreign exchange. However, in June 2005, the European Commission called for severe reductions in EU sugar prices and an end to

the current system of national quotas. The sugar sector was reengineered to face the global challenge of export competitiveness. In 2005, around 76,000 hectares were used for sugar cultivation. Since then, land for agriculture drops substantially.

Sugar cane cultivation still makes a large share of total agricultural sector. Out of the 62,327 hectares devoted to agriculture, sugar cane plantation stands at 53,464 hectares in 2013, yielding 3.8 million tonne of sugar (Statistics Mauritius 2014). Given that 1 tonne of sugar cane yields 86 litres of ethanol, the sugar cane sector can bring 4.6 million litres of ethanol per year.

To analyse whether bioethanol in Mauritius conforms to a CCD, the decision support system is applied to the Mauritian context. In order to estimate the economic and environmental feasibility sets, four indicators are required: NREB, the carbon dioxide emission avoided, LCC assessment and the price of the conventional fuel. The following sub-section shows a step-by-step process to conduct the assessment.

3.1. The System Boundary

An important milestone of a biofuel assessment is the system boundary (Figure 2). This represents the boundary of the supply-chain within which the production and distribution take place. It includes the production of raw materials to the transportation of the product for final consumption. The study defines four stages in the system boundary. Stage one relates to energy consumed and changes in CO₂ from land use changes which are internalised in the NREB and CO₂ avoided. The cost assessment at this stage will include peculiar externalities, such as the change in welfare due to demand and supply adjustments in the input and output markets when land is converted from food crop to biomass cultivation. It also takes into consideration other externalities which occur during the transformation of food crop land or other types of land, such as forests to cultivate bioethanol feedstock. Examples include the loss of ecosystem services, biodiversity, and cultural values.

Stage 2 involves the cultivation and harvesting of feedstock (which is sugarcane). This stage includes the energy consumed, CO₂ emitted and cost incurred in the: (i) production of fertilisers, herbicides and other inputs used in the cultivation stage, (ii) transportation of these inputs to sugarcane field, (iii) farming and cultivation, harvesting (manual and mechanical), (iv) irrigation, (v) loading, and (vi) transportation of sugar cane to factory and sugar processing generation (Ramjeawon 2004; Nguyen, Shabbir and Gheewala 2008; Silalertruksa and Gheewala 2009). This stage is particularly important in the cost assessment. The cost components at this stage include ground preparation, seeding and seed, fertiliser and applications, chemicals and applications, water and applications, harvest, labour and land preparation. Zhang *et al.* (2003) include the purchase of vehicles, the refuelling of infrastructure and the operation, maintenance and

repair of vehicles in their life-cycle cost assessment. Yu and Tao (2009) incorporate capital investment for the production system in the life-cycle assessment.

Stage three is the conversion of feedstock into ethanol. Electricity is used at this stage. However, bagasse as a by-product is produced in the production process. Hence, the accumulated energy, CO₂ avoided and costs have to be distributed among two products.

The fourth stage is the transportation of bioethanol to the ad-mixture plant. Distribution of bioethanol to final blending points is not within the system boundary. In stages 3 and 4, the conversion of sugar to bioethanol and the distribution of bioethanol to ad-mixture plant involve cost.

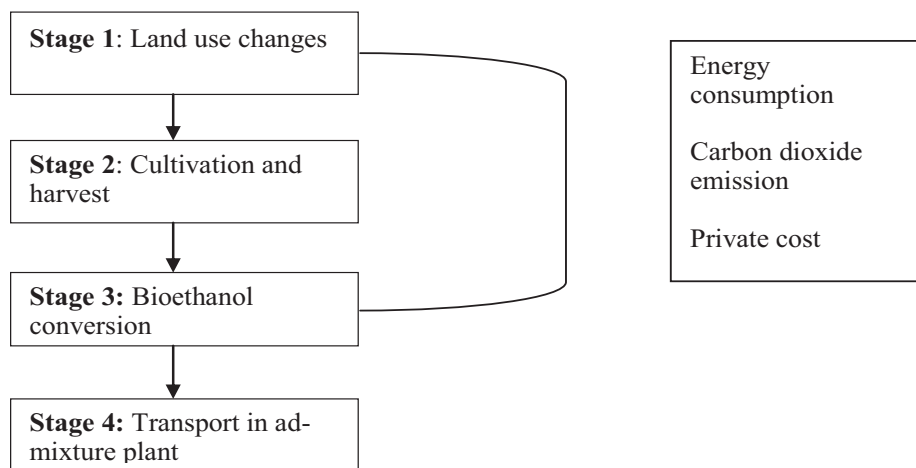


Figure 2. System Boundary

SOURCE: Author

A full description of the System Boundary is documented in Sultan and Khoodaruth (2013a, 2013b) and Sultan, Khoodaruth and Tandrayen-Ragoobur (2012). Energy, CO₂ emission and life-cycle costs are aggregated in the four stages to assess the performance (Zhou 2007). Given the System Boundary defined in this study, the LCC implies costs that are incurred from stage 1 to 4. This method is also used by Zhang *et al.* (2003), Hu *et al.* (2004) and Restianti and Gheewala (2012). The functional unit is another key element in the bioethanol system assessment. It is the measure through which the performance of a system is assessed (Garcia *et al.* 2011). The functional unit in this study is 1 ton of sugar cane and 1 litre of ethanol. Energy is measured in Megajoules (MJ) and carbon dioxide emission (CO₂) is measured either in g or kg.

3.2. Parameters for the Calculation

The parameters which are used during the energy and carbon assessment for ethanol are shown in Table 1. Area cultivated, area harvested, sugar

cane production reflect the data for 2010. Thus, one hectare of land produces 74.4 tonnes of sugar cane and one tonne of sugar cane leads to the production of approximately 0.1 tonne of sugar.

Table 1. Parameters for estimating net energy balance from ethanol production, 2010

Parameters	
Areas cultivated (in hectares)	62,100 (ha)
Areas harvested (in hectares)	58,709 (ha)
Tonnes of sugar cane cultivated	4,366,000 t
Tonnes of sugar produced	452,473 t
Net energy balance from ethanol production	
1 hectare	74.4 tonnes of sugar cane
1 tonne of sugar	9.64 tonnes of sugar cane
1 tonne of molasses	250 litres of ethanol
Functional unit	1 tonne of sugar, 1 tonne of sugar cane, 1 litre of ethanol

SOURCE: CSO (2011)

3.3. Net Renewable Energy Balance (NREB)

Net Energy Balance (NEB) identifies the gain or loss of energy from the production of ethanol by comparing the energy gain from a given unit of ethanol to the energy used in the production cycle. It is calculated as the difference between the energy content of a unit of bioethanol (usually a litre) and the energy used either in the manufacturing or in applying the inputs in the production cycle. This measure can include total fossil and non-fossil energy inputs, excluding energy recovered from system co-products, for example biogas (Nguyen, Shabbir, and Gheewala 2008; Khatiwada and Silveira 2009). However, for the purpose of this study, it may be more appropriate to evaluate the contribution of biofuel to fossil energy use reduction. Therefore, the Net Renewable Energy Balance (NREB) is defined as the energy content of bioethanol less only the fossil energy component of total energy used. The energy content of a unit of bioethanol is 21.2 MJ, compared to 32.1 MJ for gasoline.

The production stages are defined in Sultan, Khoodaruth, and Tandrayen-Ragoobur (2012). A summarised version is reported in the next section. The latter framework has been extended here to include mechanical harvesting and transportation to ad-mixture plant.

Stage 1: Land Use Changes

This stage estimates the fossil fuel used when land is converted into sugar cane cultivation to be eventually utilised as biomass for ethanol production. It includes energy used in converting land from forest and other food crop cultivation. Since, in Mauritius, there is no deforestation or shift of land from other uses, this component is zero.

Stage 2: Cultivation and Harvesting

The cultivation stage of biomass involves three different fertilisers: nitrogen, phosphorous, and potassium, applied by the following quantity per hectare, respectively: 138kg, 50kg, and 175kg. On average, 56.6MJ is applied per kg of fertilisers. The total fossil energy used for fertilisers is therefore 292.2MJ. Herbicides are applied at the rate of 7.8kg per hectare and with an energy factor of 190MJ, fossil fuel consumed per tonne of sugar cane stands at 21.1MJ.

Transportation of fertilisers and herbicides also forms part of the system boundary. In Mauritius, the fertilisers and herbicides must be transported from the harbour to the sugar cane field. On average, the distance travelled is estimated at 55km. Using the amount of diesel per km and the energy content of diesel (37MJ), fossil fuel energy for transportation of fertilisers is 1.96MJ per tonne of sugar. The same reasoning is adopted for the transportation of herbicides. The calculation shows that 0.04MJ of energy is consumed per tonne of sugar cane.

Irrigation is a common practice in biomass cultivation which uses fossil fuel. Energy content of electricity (3.6MJ) per kWh is used. However, this depends on the proportion of sugar cane field which is irrigated. In Mauritius, 25% of land is irrigated using electricity. This implies that 2.77MJ is consumed per tonne of sugar cane for the Mauritian sugar sector. Farming and harvesting use further fossil fuel at the rate of 1.05 and 1.2 litre of diesel for one tonne of sugar cane, respectively. The next component in stage 1 is mechanical harvesting. Again this depends on the proportion of the sugar cultivation which involves mechanical harvesting. In Mauritius, this figure stands at 75%. Mechanical harvesting makes use of diesel as a fossil fuel. It is observed that 22.2MJ is consumed for mechanical harvesting.

Stage 3 is the conversion of sugar to bioethanol. The electricity at this stage comes from bagasse. The calculation shows that 100.8MJ are used per tonne of sugar cane. However, this energy is counted as renewable and hence, it is not included in calculating NREB.

Stage 4 is the transportation of bioethanol to admixture plant. The average distance travelled stands at 55km with 2.8litres of diesel consumed per km. The estimate shows that 0.23MJ is consumed per tonne of sugar cane.

3.4. Distribution of Energy between Multiple Products

Since the production system of bioethanol involves more than one product, such as bagasse-based electricity, the energy used up to factory gate must be distributed between or among the final products. In the Mauritian bioethanol system, two products from sugar cane cultivation are therefore identified.

There are different methods to distribute energy, such as mass-based method, energy-content based method, displacement method, process-

purpose-based method and market-value-based method. (For a detail description, see Wang, Huo and Arora. 2011). The market-value-based method uses the economic value of individual products to allocate CO₂ emission among co-products. The premise is that CO₂ emission is distributed according to the worth of the products in the market and price is the best available indicator of how much of co-products are worth (Gopal and Kammen 2009). The economic-based method is used to calculate the apportionment ratio.

This study, as with Sultan, Khoodaruth and Tandrayen-Ragoobur (2012), uses the market-based approach to distribute energy between co-products. With the availability of data on the price of ethanol and electricity sold to the grid, the economic value of the two products can be estimated. One tonne of sugar cane can provide 86L of ethanol, and the price of ethanol is taken to be Rs20 (US\$0.67), with an indicator of 125 kWh obtained from one tonne of sugar cane at a price of Rs3.9 (US\$0.13) per kWh, the apportionment stands at 78% to ethanol (Sultan, Khoodaruth and Tandrayen-Ragoobur 2012). The total energy consumed in the production of bioethanol is shown in Table 2.

Table 2. Energy consumed in the production of bioethanol

System boundary	MJ per litre
A- Energy from the production of fertiliser NPK production	2.651
B- Energy during the production of herbicide	0.191
C- Energy in transportation of fertiliser	0.018
D- Energy in transportation of herbicide	0.0004
E- Energy during farming and cultivation	0.352
F-Energy during harvesting	0.117
G-Energy for loading	0.201
H-Energy in transportation of sugar cane to sugar factory	0.542
I- CO ₂ in irrigation	0.025
Energy as at factory gate	4.098
J- CO ₂ in conversion	0.011
K-Transportation to ad-mixture plant	0.228
Total	4.337

SOURCE: Framework extended from Sultan and Khoodaruth (2013a) and Sultan, Khoodaruth and Tandrayen-Ragoobur (2012)

The Lower Heating Value for bioethanol is 21.2 MJ. The NREB is therefore: $21.2 - 4.34 = 16.9\text{MJ}$. This implies that 1 litre of ethanol has an energy content of 16.9MJ from the production system.

3.5. Carbon Emission Avoided

In order to establish the carbon emission avoided, it is important to estimate the amount of CO₂ which is emitted during the production phase in relation to the four stages: land use changes, cultivation and harvesting, conversion, and transportation of bioethanol to ad-mixture. A full description of the

parameters used is provided in Sultan and Koodaruth (2013b). The carbon emission factors are extracted from Ramjeawon (2004; 2008) and IPCC (2006).

Again, since there is no land change due to biomass production, this stage leads to zero CO₂ emitted. In stage 2, CO₂ is emitted during the production of fertilisers (nitrogen, phosphorous, and potassium). An emission factor is attached to the production of each type of fertiliser. Diesel is used for the transportation of fertilisers and herbicides. The emission factor is taken to be 2.66kg per litre. CO₂ is also generated in the irrigation process. As explained earlier, this depends on the proportion of sugar cane field which is irrigated. The emission of electricity is attached to the irrigation factor. Farming and harvesting and mechanical harvesting use further diesel. Stage 3 is the conversion of sugar to bioethanol. The electricity at this stage comes from bagasse.

Stage 4 is the transportation of bioethanol to admixture plant. Since diesel is consumed per km., the estimate shows that 0.23MJ is consumed per tonne of sugar cane.

The results show that CO₂ emitted from the production of bioethanol per litre stands at 0.24 (Table 3).

Table 3. CO₂ emitted from the production of a litre of bioethanol

A- CO2 from fertiliser NPK production	0.095
B- CO2 emitted during prod of herbicide	0.025
C- CO2 in transportation of fertiliser	0.001
D- CO2 in transportation of herbicide	0.000
E-CO2 during farming and cultivation	0.025
F-CO2 during harvesting	0.008
G-CO2 for loading	0.015
H-CO2 in transportation of sugar cane to sugar factory	0.039
I- CO2 in irrigation	0.006
Sum	0.214
J- CO2 in conversion	0.011
K-Transportation to ad-mixture plant	0.016
Total	0.242

SOURCE: Adapted from Sultan and Koodaruth (2013b)

Given that one litre of gasoline emits 2.325kg of CO₂, and to replace one litre of gasoline for E10, the vehicle system requires 1.034 litres of ethanol, equivalent of 0.250kg of CO₂ (Table 3); one litre of ethanol eventually displaces 2.004 kg of CO₂ emissions. The assessment of the bioethanol production pathway leads to the conclusion that there are substantial environmental benefits from converting sugarcane into ethanol.

3.6. Life-cycle Cost Assessment

For the purpose of this study, the costs at each phase of the cultivation process are collected. The estimates are fully explained on Sultan, Khoodaruth and Tandrayen-Ragoobur (2012). This includes feedstock production, ground preparation, seeding, fertiliser and applications, chemicals and applications, water and applications, harvest, labour and land. The life-cycle cost of producing ethanol is shown in Table 4.

Table 4. Feedstock production costs (Rs per hectare)

Feedstock production	Costs in 2010
Ground preparation	11,494.5
Seeding and seed	7,821
Fertiliser and applications	16,353
Chemicals and applications	4,266
Water and applications	169
Harvest	8,887.5
Labour	71,929.5
Land	10,000
Total	130,920.5

SOURCE: Sultan, Khoodaruth and Tandrayen-Ragoobur (2012)

The milling costs for 2010 turn out to be around Rs 2,050 per tonne. The total production and milling costs of sugar cane are shown in Table 5.

Table 5. Total production and milling costs per tonne of sugar cane, 2010

Variables	Costs (Rs/ton)
Total sugar production costs per hectare	130,920.5
Sugar yield (tonne/hectare)	7.7
Sugar production costs per tonne	17098.9
Sugar milling costs per tonne	2,050.0
Total production and milling costs	19,148.9

SOURCE: Sultan, Khoodaruth and Tandrayen-Ragoobur (2012)

Ethanol Conversion Cost

The production cost, inclusive of financial costs and return on capital, of one litre of ethanol from cane biomass substrates is around Rs6.00 /litre (\$0.16 at the exchange rate of \$1=Rs36). The transport cost to the blending station is around Rs 2.00. Given the price of biomass of Rs12, the LCC is around Rs20 (\$0.56), with feedstock amounting to 60% (Sultan, Khoodaruth, and Tandrayen-Ragoobur 2013).

3.7. Economic and Environmental Feasibility Sets for Bioethanol Production System

The estimates of the NREB, LCC and carbon emission avoided can now be used to construct the two feasibility sets. The price of the alternative fuel is

another variable in the equation to complete the assessment. Gasoline price exclusive of tariffs, taxes, and fees represent the private costs of gasoline. Studies assessing and comparing the cost of acquiring different fuels, such as Le *et al.* (2013) calculate the costs of gasoline as the sum of the import cost (including cost, insurance and freight) and the transportation cost from the dock-warehouse to stations using an average transport distance. Consider equation 14 which redefines the economic feasibility set as:

$$LCC = \frac{(NERB)(P_{gasoline})}{y_{gasoline}}$$

..... (14)

With the current context, to be economically feasible, the LCC should be equal to \$0.29 or less. In case the LCC is above \$0.29, then it costs the economy more to get an equivalent unit of energy from conventional fuel. With an LCC of \$0.80 (adjusting for the heat content compared to gasoline), the investment is clearly not relevant. Figure 3 shows the combination of LCC and NREB which will make bioethanol economically feasible. It is observed that as the LCC rises, the NREB must be higher.

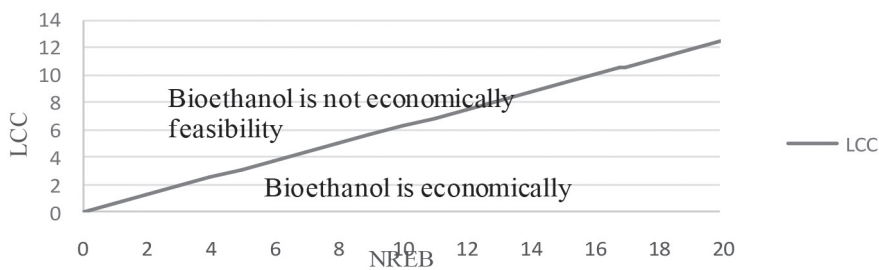


Figure 3. NREB vs LCC

SOURCE: Author

Marginal Social Cost of Carbon dioxide

To derive the environmental feasibility set which shows the climate compatible investment, an estimate of the marginal social cost of CO₂ is required. Tol (2008) reviews around 211 estimates of the social cost of carbon from 47 studies. The mean value is USD104.80 per tonne carbon. Using the latter figure that 1 unit CO₂ weights 3.67 times C, the estimates for CO₂ stand at USD300. In a recent study, Foley *et al.* (2013) conclude that on a business-as-usual path with a low mitigation, greenhouse gases may rise substantially, such as the present discounted value of carbon emission is likely to be in the order of \$550–\$950 per tonne of CO₂. This implies a rate of \$0.5–0.9 per kg of CO₂. The LCC as calculated from the study and the social cost of CO₂ are presented in Figure 4. The LCC is above the environmental feasibility set, implying that it does contribute to

climate benefits. However, it is to the left to the economically feasible set, therefore questioning its investment compared to the cost of the same energy from an alternative fuel (Figure 4).

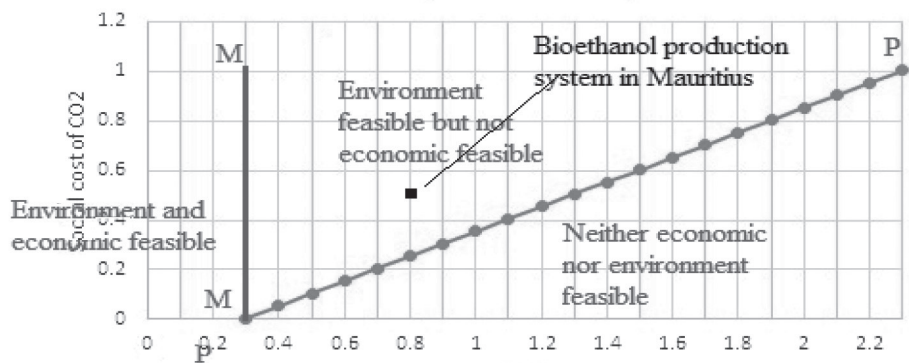


Figure 4. Climate Compatible Development Feasible Set for Bioethanol in Mauritius

SOURCE: Author

3.8.Comparative Static

This section conducts a comparative analysis of changes in the main indicators for the assessment of bioethanol. Consider the case when the avoided CO₂ is lower as shown in Figure 5. The feasible set pivots upwards. This implies that the marginal social cost of CO₂ (which reflects the climate benefit) must eventually be higher to make bioethanol a climate compatible investment.

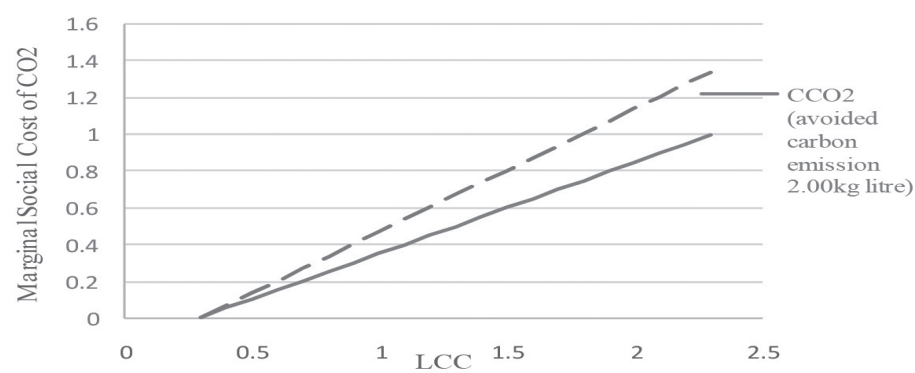


Figure 5. Changes in Carbon Emission Avoided from Bioethanol

SOURCE: Author

Changes in CO₂ avoided does not influence the economic feasibility set of bioethanol. Hence, it is not shown in Figure 5.

Changes in NREB

Figure 6 shows that changes in NREB affect the environmental feasibility of bioethanol. If the NREB was half to its level, that is 8MJ, the maximum LCC which will make bioethanol competitive is \$0.14 compared to \$0.29 with an NREB of 16MJ. A lower NREB, the environmental feasibility set is higher, implying that the marginal social cost of CO₂ needs to be higher to make it a climate compatible investment.

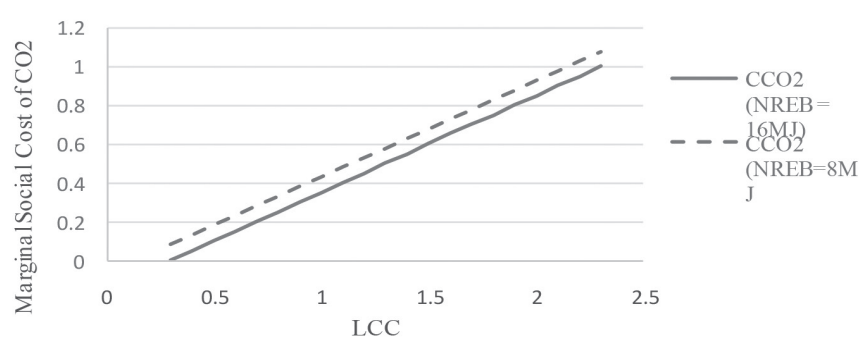


Figure 6. Changes in NREB

SOURCE: Author

Changes in the Price of Alternative Fuel

If the price of the alternative fuel changes, it affects both the economic feasibility and environmental feasibility. In case the price of gasoline doubles, the maximum LCC is \$0.58 while the CCD feasibility set shifts down as shown in Figure 7. The price of alternative gasoline is an important factor affecting the feasibility of bioethanol from both the environmental and economic perspectives.

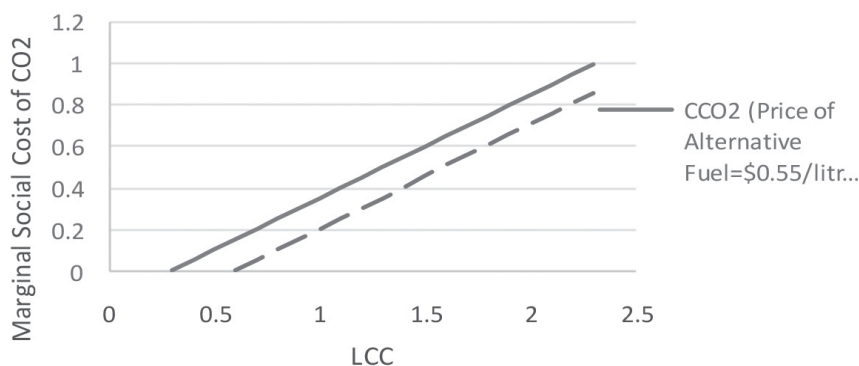


Figure 7. Changes in the Price of Alternative Fuel

SOURCE: Author

4. Conclusion and Policy Implications

There are many studies on the net renewable energy balance of ethanol production as a performance indicator. Indeed, the estimate of NREB for Mauritius, taking into account the potential of converting sugar cane production to bioethanol, stands at 16.9MJ per litre of bioethanol consumed. This represents an energy gain and adds to the positive trait of such development. By calculating the life-cycle cost of such development, from a cradle-to-grave approach, the cost stands at \$0.8 per litre. However, the cost of a litre of gasoline stands at \$0.56. Since it requires more than 1 litre of ethanol to replace an equivalent litre of gasoline, it is likely to cost the economy more to adopt bioethanol as a fuel. Another way to look at the economic performance is to estimate how much it costs the current energy system, based on fossil, to deliver the equivalent energy from a litre of ethanol using fossil fuel. This figure stands at \$0.30. From an economic perspective, such investment is scarcely feasible compared to the availability of a conventional fuel. Thus, a positive NREB is a necessary but not sufficient condition for the performance of bioethanol.

The next performance indicator is the avoided carbon dioxide emission from the use of a unit of bioethanol. In this respect, one litre of bioethanol

displaces 2.004kg of CO₂. This is a second necessary condition but still not sufficient. If bioethanol system is implemented, the economy pays \$0.5 more for every litre of ethanol instead of deriving the equivalent amount of energy using gasoline. However, it is gaining on CO₂ emission reduction. If we evaluate the marginal social cost of CO₂ at \$0.5 per kg, the climate benefits of bioethanol of reducing CO₂ is estimated at \$1 per litre, which is higher than the marginal cost of production. This is categorised as a sufficient condition to make bioethanol investment climate compatible – the monetary marginal social benefits are higher than the marginal social costs.

The life-cycle cost and the marginal social cost of CO₂ are two essential variables which determine the climate compatibility of bioethanol. Economic strategy can consequently be designed to influence the LCC. Therefore, the framework developed in this chapter derives the combination between LCC and the marginal social cost of CO₂ which will make the system both economically feasible and climate compatible. Applying the framework in this study, it is observed that bioethanol may be more beneficial to some countries than others.

This raises an important point. The climate benefits of bioethanol development are mostly global in nature while the costs associated with bioethanol are mostly local. At the local level, it is seen that bioethanol competes with conventional sources of energy and, in many respects, it lacks the competitiveness of the conventional one. Therefore, state intervention is necessary. At global level, it is observed that bioethanol from sugar has huge climate benefits which are characterised as being non-excludable and non-rivalrous. Therefore, unless the global benefits from bioethanol are internalised at local level, and countries are rewarded for their production, the lack of competitiveness may act as an impediment for bioethanol development as a climate compatible strategy. Thus, when the European Union decided to allow tax concessions for the development of fuel ethanol in 1994, a number of ethanol projects have since been initiated in countries such as Netherlands, Sweden and Spain. To a certain extent, such strategy allows to internalise the global benefits of bioethanol at local level.

A CCD for bioethanol has to bring synergies between development goals and climate change such that they may go hand-in-hand. When sugar is used as feedstock for bioethanol, trade and climate policy offer an opportunity to make bioethanol a CCD. Consider trade policy in the context of the sugar sector. A Sugar Protocol of the Lomé Convention was signed in 1974, which linked the African Caribbean Pacific (ACP) countries to the European Economic Community (EEC) whereby the EEC agreed to import specified quotas of sugar, at a guaranteed price to be negotiated annually. In Mauritius, the stable revenues from sugar exports in the 1980s helped to diversify the Mauritian economy into the tourism, financial services and manufacturing sector. In June 2005, the European Commission published

legislative proposals to reform the Sugar Protocol and this called for severe reductions in EU sugar prices and an end to the current system of national quotas. The Mauritian Government had to reengineer the sugar sector to ensure the commercial viability and sustainability of the sugar sector to maintain its multi-functional role in the Mauritian economy, at a significant social cost. Eventually, the sugar sector had to be re-engineered to face the global challenge of export competitiveness. As the price of sugar in the international markets was not sufficiently competitive compared to the cost of production in Mauritius, there was a need for a centralisation policy and to cease operations of some sugar factories. The centralisation policy also increases the distance travelled for sugar-cane field to sugar factory which eventually raises the use of fossil fuels and CO₂ emissions.

The shift of cultivation land from sugar production to bioethanol may well define an essential climate compatible development path for countries which benefitted from the EU-ACP Sugar Protocol but had to re-engineer their sugar sector given the severe reductions in EU sugar prices and the end in June 2005 of the system of national quotas. However, it is observed that the international market fails to internalise the global environmental benefits of using sugar as bioethanol feedstock.

An Ethanol Protocol may be a way to redefine trade system in relation to the agricultural sector to accommodate the global benefits in the production and consumption of sugar-based ethanol, given the associated CO₂ emission avoided. Thus, trade policy is one important channel to internalise the climate benefits of biofuel development towards the reduction of fossil fuel, improvement in the environment and safeguarding the interest of planters. With the World Trade Organisation forcing competition to take place on the basis of cost advantage, it may be time to re-think global trade strategy to support CCD for bioethanol.

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CHAPTER SEVEN

Climate-Compatible Development in the Water Sector of Ethiopia, Mozambique and Tanzania

Yohannes Aberra

Abstract

In view of the adverse impacts of climate change on the water resources, the unsustainable ‘business-as-usual’ approach to the development and management of water and related resources should be replaced by climate-compatible development. Climate-compatible development is an interface between mitigation, adaptation and development. In this chapter, three Eastern and Southern African countries viz. Ethiopia, Mozambique and Tanzania, are selected for a comparative study of the existing groundwork to help shift development in the water sector to a climate-resilient and carbon-neutral development. The three countries, which have registered very high growth rates, need to make their development sustainable in the face of climate change. Qualitative information was extracted from 24 formal national and international documents. Water-related adaptation and water-implied mitigation actions are described and evaluated in light of their merit for climate compatible development in the water sector. Water policies and coordinating institutions are evaluated in terms of their significance as enabling environment for the climate-compatible development in the water sector. Drivers and barriers for the implementation of climate-compatible development are also discussed. It is concluded that there has not been adequate stimulations for the directly water-related options as compared to the water-implied mitigation, since the latter is better financed than the former. Even the better funded mitigation actions are water-implied not water-intended. There has been little deliberate action to plan, monitor and evaluate mitigation actions in terms of how much water they have added into or subtracted from the systems. The lack of water-audit for mitigation actions has obscured the contribution of mitigation actions to adaptation in the water sector. Such a lack of synergy between directly water-related adaptation and mitigation actions with water resource implications would result in a lopsided climate-compatible development in the water sector.

Keywords: Climate change, low-carbon development, water-implied mitigation, water-related adaptation, water-resilient development

1. Introduction

1.1. Background

The motto of the UN Summit on Climate Change 2014 is “Catalysing Action”. The urgency is understandable. The latest climate report indicates that the warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and oceans have warmed, the snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased (IPCC 2013). In the UN Summit on Climate Change 2014, Ban Ki Moon, the UN Secretary General, had words of encouragement for nations of the world by stressing that climate action and economic stability and growth are complementary.

Since the industrial revolution, economic growth and the ensuing affluence lied squarely on the use of fossil fuels. The material comfort and its sources have been so much taken for granted that what these substances were doing to the very foundation of human life, not to mention the sustainability of economic growth, was not duly noticed until recently. Even after it was well known that global temperature has been rising, as it never did before in human history, humanity is split into belief and disbelief, panic and resignation, accepting and denying that the change is a result of human imprudence. Even when consensus is reached about the fact that the changing climate is anthropogenic, and for the sake of continuation of the species it is required that human kind changes its ways and means, it will not be so easy to change the technological, economic and socio-cultural status quo. Sautter (2009) called this a “global conundrum”, a situation in which emissions will be limited while still guaranteeing the right to development in a global economy firmly founded on the use of fossil-fuels.

The 20th Conference of the Parties in Lima (Peru), in December 2014, has reached a crucial decision of elevating adaptation to a global challenge that must be addressed with the same urgency, in political/legal parity and balance with mitigation (UNFCCC 2014). This is the balance described as climate-compatible development, where human development and poverty reduction should prevent climate change from getting much worse, and simultaneously endure the inevitable climate change expected this century (Cassidy 2010). Although climate-compatible development might involve substantial financial and human resources, it is an integrated and holistic ‘triple win’ (climate change adaptation, mitigation and development) and is the only sensible solution to effectively achieve development in a changing climate (Urban 2013).

Africa, burdened by the impacts of climate change, which is not its own making, will have to make a hard choice about how it would gear its development efforts aimed at ending poverty and more. In the UN Climate Summit 2014, President Barak Obama of the USA warned the countries that are struggling to build their own industries not to repeat the mistakes

others have done in what he calls the “dirty phase” of development. Mabey (2008) also reminds African policy makers that future African development should embrace the green challenge to reduce vulnerabilities to climate change impacts and ensure sustainable economic growth rather than repeat the environmental mistakes of the developed world. Climate-compatible development is already considered as a new development paradigm by many African countries; and energy, forestry and agriculture are considered to be the three key economic sectors contributing significantly towards Africa’s development and poverty reduction goals, and also the most vulnerable to the impacts of climate change (NEPAD-OECD 2011).

Although energy, forestry and agriculture remain important target sectors for climate-compatible development, water is key for all sectors (IPCC 2007) and has a pivotal role in climate change response as it serves as the fundamental link between the climate system, human society and the environment (UN 2012). This implies that climate-compatible development in the water sector is fundamental for success in the other sectors. In spite of the fact that water-related issues play a key role in regional and sectoral vulnerabilities, they have not been adequately addressed in climate change analyses and climate policy formulations (Bates *et al.* 2008). Climate-compatible development requires the synergy of mitigation and adaptation. However, strategies for mitigation are not as yet incorporated in the water sector development. It is rather only adaptation which is considered appropriate to the water sector. In IPCC (2007), water is included in the selected examples of a planned adaptation by sector not in the selected examples of key sectoral mitigation technologies, policies and measures.

1.2. Statement of the Problem

Water is a fundamental sector for Africa’s development. However, the prevailing approach to water development and management in the continent, which assumes a ‘business-as-usual’, is not sustainable in the face of climate change impacts. According to Bates *et al.* (2008), the population at risk of increased water stress in Africa is projected to be 75–250 million and 350–600 million people by the 2020s and 2050s, respectively; and more specifically, by 2025, water availability in nine countries, mainly in eastern and southern Africa, is projected to be less than 1,000 m³/person/yr. Hence, it is deemed crucial to put in place sufficient groundwork for the implementation of climate-compatible development in the water sector of Africa by identifying the opportunities and challenges inherent in the sector and other associated sectors which could facilitate or constrain expected achievements.

This study explored how solid the foundations are for the realisation of climate compatible development in the water sector in three eastern and southern African countries, namely Ethiopia, Mozambique and Tanzania. The selection of these counties was based on their location in eastern and southern Africa, and their global position in the economic growth rates

registered in recent years. According to a report by International Monetary Fund and the Economist, Ethiopia, Mozambique and Tanzania stood third, fourth, and fifth, following China and India, as three of the top five world's fastest-growing economies with an average real GDP annual growth of 8.1, 7.7, and 7.2 per cent, respectively in the year 2011 (Doing Business 2011 cited in FDRE 2011). These countries are large countries with a diversity of water resources playing critical roles in their overall development. The questions to be answered are: What are the special features of the interactions of mitigation, adaptation and development in the water sectors of the three countries? What are the drivers and barriers for the implementation of climate-compatible development in the water sector of the three countries? How much is the stage set for climate compatible development in the water sector in the three countries in order to ensure that the attained economic growth-rates become sustainable in the face of climate change? This study may serve as a template for future research on climate compatible development in the water sector.

2. Theoretical/Conceptual Literature and Analytical Framework

2.1 Theoretical/Conceptual Literature

The literature directly related to climate-compatible development is of recent origin and has not yet fully matured. Climate-compatible development is an emerging development approach, which has yet to be fully articulated and tested in practice. There is also a lack of empirical and theoretical evidence to understand how it can be planned and implemented across a diverse set of contexts (ECOFYS and IDS 2011). There are a few examples of case studies conducted on the implementation of climate-compatible development. The studies have focused on one or the other aspects of climate-compatible development implementation. Dyer *et al.* (2013) identified the characteristics of partnership models that can lead to successful delivery of climate compatible development projects by analysing case study data from two projects in Zambia; Stringer *et al.* (2014) on multi-stakeholder, multi-sector partnerships in the Democratic Republic of the Congo, Mozambique, Zambia and Zimbabwe; and assessment of the extent of climate compatible development policy practice through the lens of 'no-regrets', 'low regrets' and 'with regrets' decision making (Tompkins 2013). Nevertheless, these project-focused studies are not extensive and inclusive enough to be sufficiently synthesised to serve as strong theoretical and paradigmatic foundations.

Climate-compatible development as a new paradigm to development has not just sprung into existence without significant historical backdrop. The precursors of climate compatible development can be traced to as far back the late 1980s, in the famous Bruntland report: '*Our Common Future*'. In this report it was recommended that concern for the environment must be translated in terms of environmental strategies for achieving sustainable

development through greater co-operation among developing countries and between countries at different stages of economic and social development (UN 1987). The 'Earth Summit' of Rio de Janeiro in 1992 was another significant milestone for environment-sensitive development. One of the principles of the Rio declaration on Environment and Development is that nations must acknowledge the responsibility they bear in the international pursuit to sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command (UN 1992a).

In the same year, a global consensus was reached in the form of the signing and ratifying of the UN Framework Convention on Climate Change (UNFCCC) in which only one side of the climate-compatible development was emphasised. In the main objective of the UNFCCC, it was stated that the parties to the Convention should achieve stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner (UN 1992b). The Kyoto Protocol, signed and ratified by most countries of the world, was a mechanism in pursuit of the ultimate objectives of the UNFCCC. Approach that was recommended for the non-Annex I countries to attain sustainable development and assist parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments within the framework of the Protocol was the Clean Development Mechanism (UN 1998). Even though the stated ultimate objective of the UNFCCC and Clean Development Mechanism mark a radical shift away from the business-as-usual approach to development, they were focused on mitigation alone.

The need for a change in the approaches to development is also hinted in the United Nations Millennium Declaration: 'The current unsustainable patterns of production and consumption must be changed in the interest of our future welfare and that of our descendants' (UN 2000). Although logically an extension of the environment and development debate, which has been on the spotlight since the Rio-Summit, climate change until recently was viewed largely as an environmental concern of little relevance to development policy-makers or practitioners (Huq, Reid and Murray 2006). Climate change and development have been addressed in largely separate circles in both research and policy (Swart, Robinson and Cohen 2003). In recent years, there is a growing recognition of the nexus between climate change and development. The nexus gets its expression in the three-way interface between mitigation and adaptation, as components of climate change responses, and development. Nowadays, the promotion of and advocacy for the nexus, which has come to be known as climate compatible development, is gathering momentum. Notable in this regard is the support provided to decision-makers by the Climate and Development

Knowledge Network (CDKN) in designing and delivering climate-compatible development.

Mitchell and Maxwell (2010) defined climate-compatible development as development which moves beyond the traditional separation of adaptation, mitigation and development strategies and minimises the harm caused by climate impacts while maximising the many human development opportunities presented by a low-emissions and more resilient future. The well-known schema graphically representing three-way interaction of the constituents of climate-compatible development is shown as Fig.1. The schema depicts the nexus among the constituents in two levels. **Level one:** the interface between mitigation strategies and development strategies resulting in low carbon development; the interface between adaptation strategies and development strategies resulting in climate-resilient development; and the co-benefits arising from the interface between mitigation and adaptation. **Level two:** Climate-compatible development resulting from the interface between low carbon development and climate resilient development.

One element of the climate-compatible development-triad is mitigation. It is a human intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC 2014a); while the second of the triad is adaptation which is a process of adjustment to actual or expected climate change impacts (IPCC 2014b). The third element in the climate compatible development-triad is development strategy. Development strategy is about the pathways by which development objectives are attained.

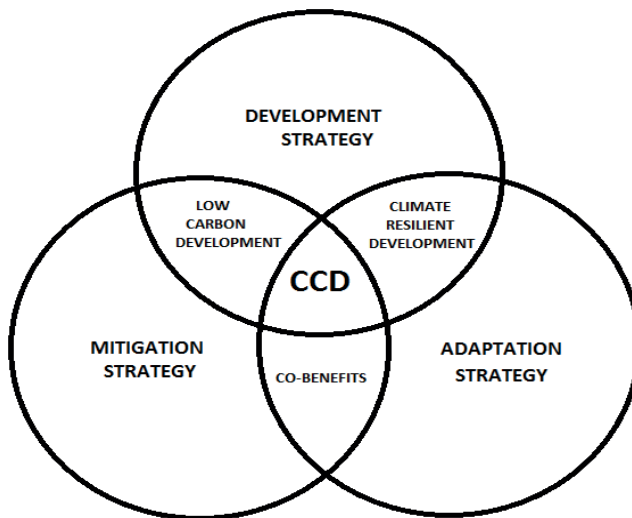


Fig. 1. Climate-Compatible Development

SOURCE: Mitchell and Maxwell (2010)

There could be clean and green or dirty and grey pathways or somewhere between the two. The choice depends on the perceptions and political and economic world-views of policy makers. One of the interfaces ultimately leading to climate-compatible development is the synergy between mitigation strategies and development strategies. Low-carbon development is the outcome of the combined effect of mitigation strategies and development strategies. According to Mulugetta and Urban (2010), low carbon development is classified into low carbon growth and low carbon lifestyles; where in the former, the economy produces goods and services with low carbon emissions resulting from changes in technological innovations. Low carbon lifestyles pertain to the ability of consumers to reduce emissions by consuming climate-friendly products. This is accomplished through behavioural changes and supportive policies coming in the forms of better public service delivery and market access for green products. For the Least Developed Countries, an international framework should be put in place to assist them in the decarbonisation of their economies and compensate them for measures they undertake that go beyond their immediate development interests (Bowen and Fankhauser 2011).

Another interface in the CCD-triad is the synergy between adaptation strategies and development strategies. The outcome of this interaction is climate-resilient development. Keessen and van Rijswijk (2012), define resilience in a dynamic approach as the capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks. A particular level of climate resilient development is attained by building a knowledge base, integrating adaptation into key policy areas, and employing a combination of policy instruments (Keessen and van Rijswijk 2012). The third interface in Level one of the CCD-triad is the synergy between mitigation and adaptation strategies. This particular combination results in co-benefits, which are more than the sum of the two strategies. Four types of inter-relationships between adaptation and mitigation are identified by Klein *et al.* (2007,) as: 1) adaptation actions that have consequences for mitigation; 2) mitigation actions that have consequences for adaptation; 3) decisions that include trade-offs or synergies between adaptation and mitigation; and 4) processes that have consequences for both adaptation and mitigation. Adaptation and mitigation can complement each other and together can significantly reduce the risks of climate change (IPCC 2007).

In addition to complementarity, the synergy also helps in the exercise of caution where actions in one strategy do not have adverse effects on the other. Adaptation actions should be mindful of such tradeoffs as greenhouse gas emissions in the process of adaptation responses (Browne and O'Neill [NY]). Mitigation strategies such as energy efficiency and the use of renewable energy reduce loss of natural habitat from avoided deforestation for fuel; and bioenergy plantations, forestation and re-forestation as carbon sequestration strategies can restore degraded land,

manage water runoff, retain soil carbon and benefit rural economies in their efforts to adapt, though the expansion of such carbon sinks could compete with food production and negatively affect biodiversity (IPCC 2007).

For the water sector, Cruden (2015) has exhaustively documented the interplay between mitigation and water resources management actions as follows:

- 1) mitigation actions having beneficial effects on water resources: slowing deforestation, conserving water resources, reducing runoff, controlling erosion and reducing siltation of rivers;
- 2) mitigation actions having adverse effects on water resources: underground carbon capture poses risk to groundwater quality; bio-energy crops and forestation increases water demand; land management may promote water-use efficiency, but can adversely affect surface water and ground water quality;
- 3) water resources management having adverse effects on mitigation: hydropower is emission-free, but methane may be emitted; irrigation can enhance carbon storage through enhanced yield, but emissions may occur from the energy used to deliver the water; wastewater treatment and purification technologies may release methane and nitrous oxide; and use of energy for desalinisation generates emissions; and
- 4) water resources management having beneficial effects on mitigation: residue returned to the field to improve water-holding capacity will sequester carbon through both increased crop productivity and reduced soil respiration.

Climate-compatible development has key drivers like the need to adapt, new economic opportunities, climate finance, and strong leadership; and it also has some key barriers to its implementation, such as costs associated with change, interest groups opposed to change, lack of awareness or trusted information, short-termism, and institutional and technological constraints (Ellis, Cambray, and Lemma 2013). The most important practical challenge that developing countries are facing in the implementation of climate-compatible development is designing to meet international support requirements at the expense of domestic priorities supported by domestic institutions, legislations and budget systems (CKDN 2010).

2.2. Analytical Framework

The framework for the analysis of climate-compatible development in the water sector necessitates the recognition of the interplay of the three components: mitigation, adaptation and development. Although the basic analytical framework for the study of climate compatible development is the schema by Mitchell and Maxwell (2010) in Fig. 1, sector-specific adaptations are needed to capture the special features of the sector resource. The analytical framework employed in this research is organised as the

interface between water-related adaptation, water-implied mitigation, and water resources development (Fig.2).

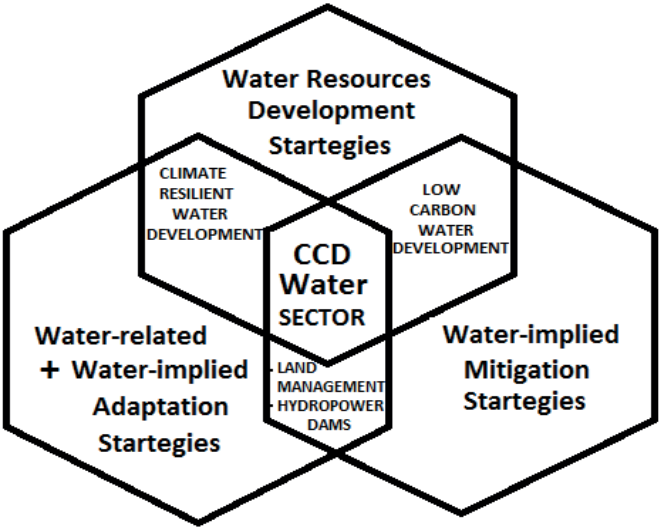


Fig. 2 Analytical Framework for Climate Compatible Development in the Water Sector

SOURCE: Compiled by Author, based on Mitchell and Maxwell (2010)

Water-related and water-implied adaptation strategies interface with water resource development strategies, resulting in climate-resilient water development. Water-implied mitigation strategies interface with water resource development strategies, resulting in low-carbon water development; and at the interface between water-related and water-implied adaptation strategies and water-implied mitigation strategies lie land management and hydropower dams. The synergy between climate-resilient water development, low-carbon water development, and land management and hydropower gives climate-compatible development in the water sector. The new climate-compatible development in the water sector is radically different from the way water resources development is done up to now. According to the World Bank (2007), water resources development entails a variety of activities which enable water to be controlled, such as, the construction of storage and flood control dams, diversion works, protection works, such as dykes and levees, inter-basin water transfers, and canals. The new approach to water resources development ensures that control and use of water should at the same time enable resilience of the resources and users and be run on zero or near zero emissions.

3. Methodology

This chapter is the result of qualitative research based on compilations from secondary numerical as well as textual information derived from 24 country-documents listed in the reference section. The data in the documents is published by the respective national governments and reputable international organisations ensuring, to a large extent, reliability and validity. The use of national level aggregated data is justified on the ground that climate compatible development is still in its inception, requiring policy-making and mainstreaming at national level to facilitate its full-fledged adoption as a sustainable approach to development. The compilations are tabulated country-wise to facilitate comparison and/or just discussed in the text. This particular subject is a nascent field of research. The reports and research outputs on climate-compatible development to date have been descriptive. No rigorous analytical models or techniques have emerged as yet; and this research does not attempt to create one.

2.7. Geographic, Socioeconomic and Environmental Profiles of Ethiopia, Mozambique and Tanzania

Ethiopia, Mozambique and Tanzania are southern and eastern African countries. According to Central Intelligence Agency (2015_{a,b,c}), the largest of the three, in terms of surface area, is Ethiopia with a total land area of 1.1 million km². Of the total area of Ethiopia nearly 10% is covered by water bodies. By 2003 the total irrigated land accounted for only 2% of the arable land. Ethiopia is a landlocked country; whereas, Mozambique and Tanzania possess 2470 and 1424 kilometres of coastline, respectively. This gives the latter two something additional to worry about with regard to climate-change-induced sea level rise and coastal flooding. Close to 7% of the total area of Tanzania, which is 0.95km², is covered by water surface. The 1.7% proportion of irrigated land to the arable land by 2003 was even lower than that of Ethiopia's. With 2.3 % of the arable land by 2003, irrigated land area in Mozambique is only slightly higher than that of Ethiopia's. Proportions lying between 1.7 and 2.3, the three countries have a very low level of development of irrigated agriculture. Mozambique is the smallest of the three in area size. Out of the 799,380 km² of area of the country, only 1.6% is occupied by water bodies. Although Mozambique has a much smaller proportion of water surface area, the 217 km³ of renewable water resource is much higher than the 122 km³ and 96 km³ for Ethiopia and Tanzania, respectively. How much of it is produced internally is critical to water security of the countries. Ethiopia excels in this regard, where the entire renewable water resources are produced internally. Tanzania also has close to 90% of its water resources produced internally. Nearly half of the renewable water resource of Mozambique is contributed from outside the country. Despite the relative abundance of renewable water resources in these countries, the level of extraction remains negligible. By 2011, freshwater withdrawal was 5.3%, 4.5% and 0.4% for Tanzania, Ethiopia and Mozambique respectively; and 70–90% of this was for agriculture.

(Central Intelligence Agency 2015_{a,b,c} and The Encyclopedia of Earth [N.D.]).

Mean annual temperature and rainfall trends have been observed and projected for the three countries. Since 1960, mean annual temperature is observed to have increased by 0.6°C in Mozambique, 1°C in Tanzania and 1.3 in Ethiopia. The average rate of increase per decade has been 0.13°C for Mozambique, 0.23°C for Tanzania and 0.28°C for Ethiopia. High and low temperature projections are made for the years 2060 and 2090. It is projected that Ethiopia will experience a mean annual temperature rise of 1.1°C to 3.1°C by the year 2060 and 1.5°C – 5.1°C by the year 2090. For Mozambique the projection is 1.0°C to 2.8 by 2060 and 1.4°C to 4.6°C by 2090. The mean annual temperature in Tanzania is expected to increase by 1.0°C to 2.7°C by 2060 and 1.5°C to 4.5°C by 2090. Observed trends and projections for the mean annual rainfall values for Ethiopia, Mozambique and Tanzania are not as concrete and as amenable for comparison as the observed and projected mean annual temperature values. In Tanzania, annual rainfall decreased at an average rate of 2.8mm per month (3.3% per decade); but contrary to past trends it is projected to increase in the future. Although the observed trend for Mozambique has decreased at an average rate of 2.5mm per month (3.1% per decade) between the years 1960 and 2006, no substantial change in annual rainfall is expected in the years ahead except for decreases in dry seasons and increases in wet seasons. The strong variability of rainfall in Ethiopia has not made detection of long-term trends difficult; but overall increase of mean annual rainfall is expected in the decades to come. (McSweeney, New and Lizcano 2008_{a,b,c}).

Ethiopia, Mozambique and Tanzania are economically underdeveloped countries trying hard to get out of the poverty trap. Tanzania is one of the world's poorest economies in terms of per capita income; so is Ethiopia, although a higher level of GDP growth has been maintained in the recent years. Over half of the population of Mozambique remains below the poverty line. There is an overwhelming dependence on the low productivity subsistence agriculture of the three eastern and southern African countries, particularly in terms of employment. In Tanzania, agriculture contributes a quarter of the GDP and 85% of the exports. Agriculture in Ethiopia has suffered several decades of poor cultivation practices and frequent drought. This has also been the case to a certain extent in Mozambique and Tanzania, too. However, recent developments in the three countries have shown a push by the government of Ethiopia to diversify the economy into manufacturing, textiles, and energy generation. It is hoped that revenues from natural gas, coal, titanium and hydroelectric power generation would overtake donor assistance in Mozambique. Tanzania, which is said to have completed a transition to a liberalised market economy has achieved high overall growth rates based on gold production and tourism. The implications, for the adaptive capacity to climate change impacts of the majority of people and their livelihoods, of such growth rates against a background of widespread poverty in the three countries could be a

sufficient reason for concern. Climate-compatible development certainly requires the attainment of high enough growth rates for the generation of revenues to pay for planned adaptation at the macro level. However, the critically needed adaptation at grassroots level obliges distributive justice. (Source: Index mundi (2014_{a,b,c}))

There is a great deal of similarity between Ethiopia, Mozambique and Tanzania in terms of the natural hazards they frequently suffer from, environmental issues they need to address, and international environmental conventions they are parties to. Drought is a common scourge for the three countries; and floods and cyclones add a great deal to the vulnerabilities of livelihoods in Tanzania and Mozambique. Deforestation, soil degradation, and desertification are grim environmental realities in Ethiopia and Tanzania. Desertification in the interior and pollution of surface and coastal waters are worrisome environmental problems in Mozambique. Including the Kyoto protocol, Ethiopia, Mozambique and Tanzania have all signed and ratified conventions pertaining to biodiversity, climate change, desertification, endangered species, hazardous wastes, and ozone layer protection. Mozambique and Tanzania have ratified the law of protection of the sea. (Central Intelligence Agency (2015_{a,b,c})).

4. Climate Change Responses in the Three Countries

Drawing from the Federal Democratic Republic of Ethiopia (2011), Division of Environment (2012) and Ministry for the Co-ordination of Environmental Affairs (2012), this section reviews climate change responses in the three countries. Africa in general, and Ethiopia, Mozambique and Tanzania in particular, are suffering from climate-change externalities. Their development efforts are being adversely affected by the impacts of climate change. Although they are not the causes of their predicament, they are obliged to join the international community in the systematic response to climate change. Three of them are: parties to the UNFCCC, ratified the Kyoto Protocol, and submitted the Initial National Communication and National Adaptation Programme of Action to the UNFCCC. The culmination of the organised response to climate change for Ethiopia, Mozambique and Tanzania has come in the form of the formulation of climate change strategy documents. The documents are: the National Climate Change Adaptation and Mitigation Strategy for Mozambique 2012; the National Climate Change Strategy for Tanzania 2012; and the Climate-Resilient Green Economy Strategy for Ethiopia 2011.

The strategy document for Tanzania covers adaptation, mitigation and cross-cutting issues benefiting from the Copenhagen Accord, Cancun Agreement and Durban Platform for Enhanced Action. These opportunities include technology transfer and Reducing Emissions from Deforestation and Forest Degradation Plus (REDD+) Mechanism. Financial sources for the implementation of the strategy are the Fast Start Climate Fund and the

Green Climate Fund, which aim to promote the paradigm shift towards low emission and climate-resilient development pathways. The same holds true for the climate change strategies of Mozambique and Ethiopia. The strategy for Tanzania envisages achieving sustainable development in line with the Five Years National Development plan and the Tanzania Development Vision 2025. Integrating the climate change strategies in the national planning process is also done in Mozambique and Ethiopia. The five-year (2010/11–2014/15) national plan in Ethiopia is “the Growth and Transformation Plan” (GTP). Similar to that of Tanzania, the terminus year for the strategies for Mozambique and Ethiopia is 2025. For Ethiopia, that year is when the level of a middle income country is hoped to be attained. This implies that the time framing of the implementation of the strategies is influenced more by national aspirations and priorities than by international climate change response timetables. The concurrence of the year 2025 for the three countries is not explained in the documents.

The implementations of the climate change strategies are led by the National Climate Change Focal point (Division of Environment) within the Office of the Vice President in Tanzania; the Ministry for the Coordination of the Environmental Affairs (MICOA) for Mozambique; and the Ministry of Environment and Forestry (overseen by the Office of the Prime Minister) for Ethiopia. The National Climate Change Focal Point (Division of Environment) within the Office of the Vice President in Tanzania and the MICOA for Mozambique have directed climate change response beginning from the Initial National Communication and the National Adaptation Programme of Action through to the national climate strategies in Tanzania and Mozambique. In Ethiopia, there was a switch from the National Meteorological Services Agency, under the then Ministry of Water Resources which was responsible for the preparation of the Initial National Communication and National Adaptation Programme of Action, to the Ministry of Environment and Forestry. The change may be justified on the ground that the National Meteorological Services Agency may not technically be better positioned to address the broad socioeconomic issues that constitute mitigation, adaptation and development than an environmental agency. However, the excessive focus on mitigation and the apparent disregard for adaptation by the new office for coordination seems to have made the change inconsequential. The climate change strategies of Mozambique and Tanzania comprise both mitigation and adaptation, and hence, qualify as climate-compatible development strategies.

The climate-resilient green economy strategy of Ethiopia differs from the two national strategies by the conspicuous absence of adaptation strategy. The name of the strategy clearly implies both mitigation and adaptation. Green economy is equivalent to low-carbon development while climate resilient means adaptive development. The entire document elaborates the four-pillars of the strategy, viz. low emission crop and livestock production, protection and re-establishment of forests as carbon-sinks, expanding the production of clean energy through hydropower, and shifting to energy-

efficient technologies in transport, industries and buildings. It is admitted in the strategy document itself that climate resilience is not included, but will be added over the coming months. Even five years after the climate-resilient green economy strategy of Ethiopia was launched, there is no sign of any addendum about climate resilience into the strategy document. The Ethiopian Plan of Adaptation for Climate Change (EPACC), which is claimed to be appended to the all-mitigation Climate Strategy of Ethiopia, is a document detailing the implementation mechanisms rather than what is to be implemented. Adaptation could have benefited from a better timing of the NAPA. The NAPA was prepared and submitted at least five years before the climate change strategies came into effect in Ethiopia, Mozambique and Tanzania. It is hard to understand in what framework adaptation priorities were identified and planned.

5. Climate-Compatible Development in the Water Sector of the Three Countries

5.1. Water-related Adaptation

In this section, water-related adaptation actions are discussed (Table 1) as they are proposed in the three documents— Initial Communications, NAPAs, and the Climate Change Strategies— for Ethiopia, Mozambique and Tanzania.

Proposal from Ethiopia about water-related adaptation can be traced back to the Initial Communications to the UNFCCC in 2001. The options mentioned include such strategies as market-based water allocation, conservation of water, pollution control, and river basin planning for Awash and Abbay Rivers. The National Adaptation Programme of Action submitted to the UNFCCC six years later proposed adaptation options, for the water sector, which were a different set of strategies from the previous. These were, small-scale irrigation, water harvesting, and wetland management. The document for Climate Resilient Green Economy 2011 for Ethiopia had not included adaptation strategies. However, there are at least two actions in this all-mitigation document, watershed management and wetland management, which are essentially water-related adaptation. They must have been proposed as mitigation options in view of their importance for sequestration purposes. Due to unavailability of clearly listed adaptation options in the Ethiopian climate strategy and subsequent documents, the following proposed adaptation strategies recommended in a RiPPLE-HCS National Policy Engagement Workshop are included here: increasing storage, water-use efficiency, improving water conservation, rainwater harvesting, and tackling and preventing floods.

Table 1. Water-related adaptation options proposed in the Initial Communications (IC), National Adaptation Programmes of Action (NAPA), and the Climate Change Strategies (CCS)

Document	Ethiopia	Mozambique	Tanzania
IC	• Market based water allocation • Conservation of water • River basin planning for Awash and Abbay	• Integrated river basin master plan • Small dams • Public awareness water conservation • Mapping, forecasting flood and drought	• Building reservoirs • Inter-basin water transfers • Rainwater harvesting • Water-saving technologies • Re-cycling water • Catchment protection
NAPA	• Small scale irrigation • Rainwater harvesting • Wetlands management	• Monitor river water levels to forecast drought and floods.	• Rainwater harvesting • Water storage • Catchments management • Small-scale irrigation
CCS	• Watershed management • Wetland management ○ Increasing storage ○ Water use efficiency ○ Water conservation ○ Rainwater harvesting ○ Tackle and prevent floods	• Community dams • Rainwater harvesting • Water transfer • Desalination • Storage capacity • Flood control, • Aquifer refilling	• Protecting catchments • Water recycling • Rainwater harvesting

SOURCES: Compiled by author from (Table 1: B_{1, 2, 3}; C_{1, 2, 3} and F_{1, 2, 3}). MoWR -NMA (2007, 2001), MfCEA (2012, 2007, 2003); MoSE DE (2012, 2007, 2003); and FDRE (2011).

- Added from RiPPLE-HCS National Policy Engagement Workshop (2011)

Water-related adaptation options in Mozambique and Tanzania are inclusive of what are normally considered to be best strategies. In Mozambique's Initial Communications to the UNFCCC 2003, integrated river basin master plan, small dams, public awareness water conservation, and mapping for forecasting flood and drought were proposed adaptation options. Except for the monitoring of river water levels to forecast drought and floods, the adaptation proposals in the National Adaptation Programme of Action 2007 did not match with the previous. The National Climate Change Adaptation and Mitigation Strategy 2012 for Mozambique was more exhaustive in terms of the inclusion of key adaptation options, namely, community dams, rainwater harvesting, water transfer, desalination, storage capacity, flood control, and aquifer refilling. There was more consistency in Tanzania's adaptation proposals in the three documents. This is specially the case for rainwater harvesting, catchment protection, and water recycling. Building of reservoirs for water storage appears in the Initial Communications and in the NAPA while missing from the Climate Strategy. Inter-basin transfer seems to have been abandoned as an option after the Initial Communication. Hydropower constitutes a mitigation-cum-adaptation action in Ethiopia and Mozambique, being more intensive in the former than in the latter. Rainwater harvesting is identified as an adaptation option in the three countries. This is a key adaptation strategy because it is a key to several other adaptation actions, such as increasing storage capacity, aquifers refilling, flood control, watershed management, water conservation, small-scale irrigation, and wetlands management.

5.2. Water-implied Mitigation

Adaptation, in contrast to mitigation, does not have an opportunity for self-financing. There is a high correlation of vulnerability to climate change impacts and poverty. Poor countries cannot afford to finance planned adaptations without support from rich countries. There is huge cash flow from governments and the private sector of the developed countries, who have emission quotas to fulfil under the Kyoto Protocol, to the poor countries who are interested to engage in emission-trading through the Clean Development Mechanism (CDM) and REDD+. Mitigation options with implications for adaptation in the water sector have the benefits of being self-financed. This feature has made the options more popular in the countries of the developing world. This is more so in Ethiopia where climate change response has been skewed in favour of mitigation. In this section, comparisons are made first between the three documents country-wise; second, the three countries are compared document-wise; and third, mitigation options common to the three countries are identified (Table 2).

Table 2. Water-implied mitigation options proposed in the Initial Communications (IC) and the Climate Change Strategies (CCS)

Document	Ethiopia	Mozambique	Tanzania
IC	• Forest management, afforestation, reforestation, agro-forestry • Conservation tillage, • Composting solid waste	• Reforestation	• Forest protection, afforestation, reforestation, natural regeneration and agroforestry
CCS	• Reduced deforestation for cultivation through intensive agriculture (less land), • Reduced forest degradation, increase afforestation, reforestation, agroforestry, • Conservation agriculture (minimum or zero tillage) • Livestock • Output/head of cattle • Lower-emitting animals • Mechanise draft power • Biofuel • Area closure to rehabilitate degraded areas	• Conservation agriculture • Forest management and natural regeneration • Reduction and recycling of waste	• Management of agricultural wastes • Forest management, afforestation, reforestation, household plantations, agro-forestry, non-wood construction materials. • Improved soil and land management

SOURCES: Compiled by author from FDRE (2011), MfCEA (2012, 2003), and MoSE DE (2012, 2003) and MoW- -National Meteorological Agency (2001).

Actions related to forests have been at the top of water-implied mitigation options in the Initial Communications and the Climate Strategies of Ethiopia, Tanzania, and also Mozambique to a lesser degree. Reducing deforestation through intensive agriculture, which uses lesser land area and reducing forest degradation through reforestation, afforestation,

agroforestry and household plantations to increase the area under forest play significant roles in carbon sequestration. Afforestation or reforestation could have benefit to water resources by preventing loss of soil moisture through evaporation. In addition, groundwater recharge could be enhanced and flooding reduced as the forest canopy minimises rainwater runoff. Furthermore, forests serve as windbreaks reducing wind-induced desiccation of the soil.

Conservation tillage reduces emission from the overturning of soils during tillage also helps to retain soil moisture, enhance rainwater infiltration, and reduce flooding. It was included in the Initial Communication and the Climate Strategy of Ethiopia, and also the Climate Strategy of Mozambique. Area closure to rehabilitate degraded areas in the Climate Strategy of Ethiopia and Tanzania's improved soil and land management as mitigation options, in both documents, can also have similar water resource implications. Control of emissions through composting of solid waste in the Initial Communications of Ethiopia, reducing and recycling of waste and managing agricultural waste in the Climate Strategies of Mozambique and Tanzania, respectively contribute to the reduction of water pollution. Three options are proposed in the Climate Strategy of Ethiopia to reduce the emission of methane from livestock production, select lower-emitting animals like poultry and raise output per head of animal and mechanise draft power to reduce the number of animals. As the sizes and numbers of animals decrease, the amount of water consumed also decreases, saving water for other more critical uses.

5.3. Climate-resilient and Low-carbon Water Development

Climate-compatible development in the water-sector implies that vulnerability to climate change impacts is diminished and resilience enhanced; and this must be accomplished with a minimum carbon-footprint. It is also required that low-carbon development of water resources must enable effective adaptation for climate change resilience. In the previous sections, directly water-related adaptation strategies and mitigation strategies which have implications for water are discussed. Most of the directly water-related adaptation options are free of emissions and qualify as carbon-neutral. Nevertheless, a few water-related adaptation options, like inter-basin water transfers, re-cycling of water, small-scale irrigation, and desalination require energy use to varying degrees and could have relatively larger carbon footprints. Hence, it is crucial for these key adaptation strategies to use cleaner energy sources, such as hydropower. Ethiopia, Mozambique and Tanzania get over 90% of their electricity from hydropower. This may suggest that the aforementioned adaptation options could be made emission-free. The challenge is that such adaptation options are adopted in localities which normally are farther away from power grids. Connecting such mostly isolated localities to the national-grids may incur very high cost which cannot be justified in economic terms. Some of the key water-implied mitigation options may be detrimental to climate

resilience in the water sector. Afforestation or reforestation may also wreck the water balance of a locality by exposure of water droplets to evaporation from leaf surfaces, and water guzzling large trees and the associated loss of water through evapo-transpiration. Biofuel production, a mitigation option in the agriculture sector, requires the use of greater quantities of water, harming resilience in the water-sector.

6. Enabling Environment, Drivers and Barriers of CCD in the Water Sector

6.1. Policies and Institutional Arrangements

The realisation of climate-compatible development requires that its objectives are in full agreement with the existing policies. In some cases, related policies and laws may predate new phenomena that require action and yet serve as sufficient enabling environment. In other cases, the need for urgent actions may require that new policies be formulated partially or fully. Water policies of Ethiopia, Mozambique, and Tanzania came into force in 1999, 1995, and 2002, respectively. All of the three policies predate the endorsement of climate-compatible development as the only pathway to sustainable development, particularly for the developing countries, in the face of imminent threats of climate change. Timing is important because it is the prevailing state of affairs, more often than not, that compels the formulation of policies. In this section, the extent to which the existing policies of water, which predate the resolve of nations around the world to gear their development endeavours in the direction of climate compatibility, can serve as adequate frameworks for action is explored.

Although the water policies of the three countries predate the advent of climate-compatible development, Ethiopia's water policy happens to be more inclusive with most of the required policy that could serve as an enabling framework for most of the proposed water-based adaptation options proposed in the national climate change documents (See Tables 3 and 4). In this regard, there is lesser urgency to revise the water policy of Ethiopia with the view to match it with the requirements of climate-compatible development in the water sector. However, this statement of adequacy pertains only to the directly water-related adaptation options. Despite the cross-sectoral nature of water resources, water-related policies that lie in other sectors are the responsibility of those sectors in terms of policy making. For example, forest policies, agricultural policies, health policies, and environmental policies that have water-related components remain to be the prerogatives of the respective sectoral ministries or agencies. Mitigation options having water implications, like afforestation or reforestation, land management including conservation tillage, livestock management, biofuel production, area-closure to rehabilitate degraded areas, and waste management, fall outside the sphere of operating water ministries or agencies. This makes it hard for the water sector to follow up

gains or losses pertaining to the effects on water of mitigation actions in other sectors.

The most extreme case is in the climate strategy of Tanzania. Except in waste management, the Ministry of Water does not appear as a key actor in important water-implied mitigation sectors like energy, livestock, forestry, and agriculture. Crosscutting issues in Tanzania's climate strategy do not refer to integration of sectoral mitigation and adaptation actions but as services to be provided for sectoral activities, namely, research and development; information, communication and education; technology transfer; institutional capacity; systematic observation; disaster risk management; impact of responses; gender and vulnerable groups; planning and findings; international cooperation; climate change security; and early warning. Even from among the twelve crosscutting issues, the Ministry of Water is mentioned as key actor only in early warning. Even in water-related adaptation, the Ministry of Water is listed as one of the key actors in energy, livestock, infrastructure, other than water; but not in key water-related adaptation sectors, such as forestry, agriculture, and land use.

Table 3. Enabling policies for climate compatible development in the water sector

Country	Policies relevant to CCD in the water sector
Ethiopia	• Integrated water resources management • Water resources development, protection and conservation go hand in hand • Inter-basin transfer for drought and floods • Efficiency in water use • Rainwater harvesting • Watershed management • Recharging ground water • Small-scale irrigation • Hydropower • Storage to combat drought • Combating and regulating floods • Control wastage in using water • Using water for multiple purposes by recycling
Mozambique	• Retention and storage of water • Combating soil erosion and flood control • Balance between multiple and conflicting uses of water • Environmental water allocation
Tanzania	• Human consumption given highest priority • Priority for water-scarce areas use • Protect water resources

SOURCES: Compiled by author from MoWR (1999), The Encyclopedia of Earth (N.D.), and MoWLD (2002).

The climate resilient green economy strategy of Ethiopia is focused on mitigation in the energy, agriculture (including forestry, soil, and livestock), transport, industry, and health sectors. The representation of the water sector is restricted to energy in view of the fact that water is the dominant source of electric power. Even some directly water-related adaptation options, like rainwater harvesting and small-scale irrigation, have traditionally been the responsibility of the Ministry of Agriculture rather than under the Ministry for Water. The proposed implementation mechanism of the climate strategy of Mozambique is much closer to the requirements of climate-compatible development. The implementation approach is more integrative than sectoral. The National Council for Sustainable Development coordinates actors from the public and private sectors, civil society and community-based organisations, according to a plan of action.

Table 4. Responsible organisations for the Initial Communications, CC Strategies and water

Country	Initial Communications	CC Strategy	Water sector
Ethiopia	National Meteorological Services Agency	Ministry of Environment and Forest + Ministry of Finance and Economic Development	Ministry of Water, Irrigation and Energy
Mozambique		Ministry for the Coordination of Environmental Affairs MICOA	National Directorate of Water, Ministry of Public Works and Housing
Tanzania	Division of Environment Vice President’s Office, National Climate Change Focal Point (NCCFP)	Division of Environment The Vice President’s Office, (NCCFP)	Ministry of Water and Irrigation

SOURCES: Compiled by author from: FDRE (2011), MfCEA (2012, 2003), and MoSE DE (2012, 2003) and MoWR-NMA (2001).

Unlike Ethiopia’s water policy, which sufficiently caters for the proposed water-related adaptation actions, water policy of Tanzania’s an almost exhaustive water-related adaptation options are devoid of enabling policies. The review of the water policy for the sake of implementation of the climate strategy seems to be long overdue. In fact, Tanzania had experienced a change of water policy before. The 1991 National Water Policy was revised in 2002 on the ground that, among many other factors, Tanzania signed Agenda 21. Climate compatible development is no less important

rationale for change. The adequacy of the provision of framework for water-related adaptation options, by the Water Policy of Mozambique, lies between the two extremes— Ethiopia and Tanzania. There are many adaptation options which are supported by policies; but key adaptation strategies like rainwater harvesting, water transfer, desalination, and aquifer refilling require policy underpinning.

Appropriateness and the level of placement in the organisational hierarchy of the implementing agency is a crucial determinant for success. Table 6 shows the names and levels of the organisations responsible for the Initial Communications, Climate Change Strategies, and the water sectors of Ethiopia, Mozambique and Tanzania. The coordinating body in Tanzania has remained the same beginning from the Initial Communication. The Division for Environment, which is the responsible body at the highest level, is led by the Vice President's Office of the Republic. This is indicative of the high regard bestowed to climate change related activities. The water sector is also led at ministerial level. In Mozambique, a country rich in fresh and marine water resources, the water sector is led by a Director within a very unlikely Ministry of Public Works and Housing.

Ethiopia's water sector is also led at a ministerial level; but the name of the Ministry has been changing. Initially, it was named Ministry of Water Resources. A few years later, energy was added to its name. The change was much more than a change in nomenclature. Energy (hydropower) was destined to take the bulk of the attention of the Ministry. The recent addition of irrigation to the name of the Ministry is sure to allot a greater share of resources to the irrigation and energy production sub-sectors. No doubt, this leaves smaller room for organising and funding water-based adaptation actions. No coordinating office was indicated in the Initial Communication and NAPA documents for Mozambique. The Ministry for the Coordination of Environmental Affairs is assigned the responsibility to lead the implementation of the climate change strategy of Mozambique.

There is similarity between the three countries in their assigning of environmental ministries/agencies for the leadership of the strategies; but Ethiopia has taken this a level higher by assigning another ministry (Ministry of Finance and Economic Development) to co-manage the implementation of the Climate Change Strategy. This is in-line with the desired synergy of environment and development. The former Environmental Protection Authority of Ethiopia was upgraded to the level of a ministry by adding forest to its name. The addition may be attributed to the need to create an institutional mechanism for REDD+. The Initial Communication and NAPA for Ethiopia were not prepared by the same organisation that coordinates the current climate change strategy. Prior to the preparation of the Climate Resilient Green Economy Strategy of Ethiopia, the responsibility for climate change response was moved from the National Meteorological Services Agency to the then Environmental Protection Authority. The shift may be justified on the ground that the later

may accommodate greater multidisciplinary and cross-sectorality required by climate change response than the former. However, the leadership of environmental ministries or agencies in the coordination of climate change actions was challenged in a meeting held in Addis Ababa two years ago. The key message that emerged is that climate change is not an environmental issue; rather, it is an economic and planning challenge that requires ministries of finances and planning to play a leading role (Andrade 2013).

6.2. Drivers and Barriers for Climate Compatible Development in the Water Sector

The fundamental shift from the business as usual to a climate-compatible approach to development in all sectors, including water require that the need for such far-reaching changes be full heartedly endorsed by the political leadership and the general public as well. The only way to know whether or not there is political will on the part of policy-makers is from the agreements they sign and ratify and the favourable official statements they make. Ethiopia, Mozambique and Tanzania have signed and ratified the UN Framework Convention for Climate Change (UNFCCC). In addition, the leadership of the three countries have also expressed their conviction to act in the Initial Communication documents submitted to the UNFCCC: “The preparation and submission of this Initial National Communication to the Conference of Parties of the UNFCCC demonstrates Ethiopia’s willingness and commitment to work with the international community in attaining the ultimate objective of the Convention” Ministry of Water Resources and Environmental Protection Authority (MoWR-NMA) (2001, v); “It is urgent to adopt measures of adaptation to and/or mitigation of the adverse effects of the climate change...” Ministry for Coordination of Environmental Affairs (MfCEA) (2003, p.vi); and “Tanzania has been a keen participant in various fora on climate change. In 1997, it played a pivotal role in the negotiations that led to the adoption of the Kyoto Protocol. In that year, Tanzania chaired the Group of 77.” Ministry of State-Environment Division of Environment (MoSE-DE) 2003, xiv). The personal commitment of political leaders is also critical for climate change. With regard to strong leadership, President of Tanzania has become current coordinator of African Heads of State and Government on Climate Change. The late Prime Minister of Ethiopia also served as an African emissary on climate change.

Statements of commitment and the willingness of the political leadership to be in the forefront of action for climate-compatible development is not enough. Sufficient climate finance has to be made available for a huge intervention. None of the three countries is rich enough to cover the cost from their own coffers. Tanzania, for instance, is still heavily dependent on donor support with 40% of its recurrent budget financed from Overseas Development Agency ODA (Norrington-Davies and Thornton 2011). The national Climate Resilient Green Economy Strategy of Ethiopia called for

an annual spending of \$7.5 billion while the national budget allotted for it is only 440 million per year (Zewdu *et al.* 2014). Hence, public finance alone cannot cover climate change actions. This makes external funding inevitable. However, such sources of climate finance are not so easy to come by. It is by now common knowledge that donors do not live fully up to their commitments. There are several reasons for this; one of them is the Green Climate Fund of 100 billion USD per year that was promised for developing countries by 2020, but did not materialise to any acceptable level.

The most outstanding, probably the easiest to implement, of all the climate-change responses in the developing world is the forest-based mitigation action. Besides its service as vast carbon sink, its implication for water resources, as discussed in the previous section, is very important. The implementation of afforestation, reforestation, agroforestry and forest rehabilitation, as climate change response, is largely organised around Reducing Emissions from Deforestation and Forest Degradation (REDD+). The problem with the implementation of REDD+ is the lack of consensus that surrounds it. REDD+ is the reduction of emissions and their sequestration in the forests of the developing world to allow the emission status quo to continue and/or to help slow down the pace of emission reduction in the developed world. The greater concern is how much this strategy assists developing countries to realise climate-compatible development. With regard to this, there are seemingly irreconcilable differences as to whether or not REDD+ can create adaptive capacities in the water sector for vulnerable communities and ensure sustainable development.

Bassey (2015) believes that REDD+ is a false solution to climate change that privatises and sells nature allowing industrialised countries to use Africa's forests, agriculture, soils and even water as sponges for their emissions rather than reducing them at source. This is typified by one of Envirotrade's REDD+ projects in Mozambique. The project constitutes multi-generational 'carbon slavery' where a small amount of money is paid to the communities annually for seven years, and then, according to the contracts, the farmers, their children and their grandchildren have to continue to take care of the trees for free for 99 years. In Tanzania, REDD+ is alleged to be creating social tension and corruption by pitting villagers against each other. Contrary to such allegations of exploitation, corruption and conflict generation on REDD+, the government of Tanzania considers REDD+ as an option that provides an opportunity for poverty reduction besides its emission reduction benefits. A similar view is reflected on behalf of the government of Ethiopia, by Yitebitu and Eyob (2014) that REDD+ will generate huge environmental, social and economic benefits and is of paramount importance for improved water resources management in Ethiopia. Be the debate as it may, the crux of the matter is that nations cannot afford to experiment with options whose outcomes are characterised by uncertainties. Maladaptation in the water sector that could result from

wrong choice of strategies is hard to reverse. The success of climate compatible development of water resources requires that short-termism is replaced by long-term planning with the right choice of strategies.

7. Conclusion

Climate-resilient and carbon-neutral water resources development, which constitutes climate-compatible development in the water sector, can never be attained without cross-sectoral development planning for water resources development. Even the sectoral-side of water resources development is skewed towards large-scale water projects, such as hydropower and large-scale irrigation of commercial crops, rather than adequately addressing the vulnerability of poor water users. This is typified by the emphasis in Ethiopia on hydropower and large-scale irrigation, and a similar focus on commercial irrigation in Tanzania. In Mozambique the water sector is relegated to a sub-sector of public works and housing, undermining its importance as a pivotal resource for all sectors.

There has also been more inconsistency in three strategy documents, in the identification of priority actions for water-related adaptation than for the water-implied mitigation. There has not been adequate stimulations for the directly water-related options as compared to the water-implied mitigation, since the latter is better financed than the former. Even the better-funded mitigation actions are water-implied, not water-intended. There has been little deliberate action to plan, monitor and evaluate mitigation actions in terms of how much water they have added into or subtracted from the systems. The lack of water-audit for mitigation actions has obscured the contribution of mitigation actions to adaptation in the water sector. For instance, in reforestation, afforestation and rehabilitation, more accounting is done about carbon than about groundwater recharge. Such a lack of synergy between directly water-related adaptation and mitigation actions with water resource implications would result in a lopsided climate compatible development in the water sector.

Irrespective of whether development paradigms are old or new, implementation is enabled through public policies, strategies and legislation. 'It may be ok to put new wine in old bottles; but doing the same for water is quite unhealthy'. Old policies which were tailored for particular historical settings may serve changed circumstances to a certain extent, but cannot be adequate to address the need for a transformation of the status-quo induced by climate change. Climate-compatible development in general and in the water sector in particular is not just a mere new appendage to the water sector routine. It is an overhaul of the water management system to fit a plethora of new situations. Climate-compatible development requires not only paper-work every time it is demanded from international or regional agencies but also a missionary zeal and the sense of sacrifice of a soldier to save humanity in general and the fellow citizens of the three countries from climate change-induced harm in particular.

Sidelining actions in the water sector that pertain to poverty alleviation, reduction of vulnerability to climate change of the poor and marginalised communities, and ensuring sustainable development in favour of short-term returns from emission reduction would render the idea of climate-compatible development into a delusion.

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CHAPTER EIGHT

Climate Compatible Strategies in Planning and Investment in South Africa

Theresa Moyo

Abstract

Climate change poses serious developmental challenges for the Republic of South Africa. Evidence from several scientific studies shows that while the country contributes to the climate change problem through its high carbon emissions, it is also adversely affected in many ways as a result of global warming. In response, the government has realised the urgency for a comprehensive and systematic planning framework in order to resolve those challenges. This chapter therefore aims to assess South Africa's approach to climate compatible planning and investment. It has three main objectives: firstly, to find out the rationale for climate compatible planning and investment; secondly, to find out how climate change has been integrated into the country's planning and investment systems; and thirdly, to assess the achievements which have been experienced in the process. The chapter is based on a qualitative research methodology based on secondary sources, such as reports from national and international agencies as well as published scholarly sources. It applies the climate compatible development (CCD) theoretical framework as the basis for analysis; because in an environment where poverty, inequality and economic stagnation exist, an integrated approach to development planning is necessary. Key findings show that while South Africa has been successful in developing and integrating climate compatible approaches into its planning and investment processes, the integration of developmental goals that underpin a CCD framework appears negligible. Furthermore, the implementation of climate response plans also remains quite limited. This is largely explained by the recent nature of most of the plans and also challenges of limited skills and capacity to implement CCD. The chapter recommends that the government should strengthen the institutional basis for CCD and also build the capacity in terms of knowledge and skills required for implementation.

Keywords: Adaptation, climate change, climate response, mitigation, sustainable development

1. Introduction

1.1. South Africa and the Climate Change Problem

Climate change poses serious challenges for social, economic, and human development as well as for the natural environment. Since the publication of the scientific evidence on the phenomenon of global warming, which was produced by the United Nations Intergovernmental Panel on Climate Change (IPCC) in 2005, there is global recognition that the achievement of sustainable development critically depends on, among other things, the extent to which nations will be able to integrate climate change issues in their national development planning processes. Like many other countries in Africa, South Africa has been, and continues to be, negatively affected by climate change.

The United States International Energy Information Administration (IEIA) (2009) estimated that South Africa was the 12th highest carbon dioxide emitter (CO₂) globally. (The study did not include other GHGs.) (Urban Earth 2012, 5). Its emissions were 1.49% of total global CO₂ emissions. China was the greatest contributor to CO₂ emissions, with a 25.42% share while the United States was in second place at 17.9 %. South Africa was also reported to be the largest emitter in Africa, contributing over 40% of Africa's total CO₂ emissions. Because of South Africa's carbon-intensive electricity production process, the national power utility, Eskom (Electricity Supply Commission ESCOM), has the highest direct GHG emissions (Urban Earth 2012, 10), which amounts 45% of South Africa's total GHG emissions. The country's heavy reliance on fossil fuels for the generation of its electricity and also that its mining and manufacturing industries are energy-intensive. According to the Department of Environmental Affairs (DEA) and the Development Bank of Southern Africa (DBSA), the energy sector contributed 82.3 per cent to the total GHG inventory (excluding land) in 2000 and this increased to 85 per cent in 2010 (DEA and DBSA 2013). South Africa's industry consists of energy-intensive mining and manufacturing industries. The country has also suffered from flooding and wildfires, all of which were linked to climate change. According to the Department of Environmental Affairs (DEA 2011, 26), climate-induced flooding caused damage estimated at R4 700 million, and resulted in 140 deaths whilst wildfires caused damage estimated at R1,750 million, and 34 deaths.

The situation is compounded by the prevailing socio-economic situations and the status of development. Although the United Nations classifies the country under the Medium Human Development group of countries, poverty and inequality are major challenges. According to the United Nations Development Programme (UNDP 2014, 173), while South Africa has a fairly high Human Development Index of 0.658 in 2012, which is the latest available figure, it is one of the most unequal societies in the world as reflected by its Gini Coefficient of 0.63 over the period 2003–2012

(UNDP 2014, 170). It also recorded a gender inequality index (GII) of 0.461 in the same year. This reflects that gender inequality is still higher compared to more industrialised countries. South Africa also has a low employment to population ratio, estimated at 48.6 % in 2012 (UNDP 2014). Recent estimates by Statistics South Africa (StatsSA 2014, iv) show a high national unemployment rate of 25.1%, which, although lower than what prevails in most African countries, is much higher than the situation in the industrialised economies. Youth unemployment is even higher than the national average. Rural poverty also remains a challenge in the country. Many rural households in South Africa are not connected to the electricity grid and therefore rely on other sources of energy such as wood, gas, dung, and paraffin, which contribute to carbon emissions. They also lead to deforestation which reduces carbon-absorption capacity of the environment and also leads to soil degradation. A reliable source of energy within dwellings is an important component of well-being. Access to energy within the household for lighting, cooking and heating is especially beneficial for women as they are most often charged with sourcing energy; which is unpaid work, and expends energy that could be devoted to other activities such as food production. Moreover, households which are reliant on wood as a primary energy source will contribute to the land degradation (DEA 2011, 28). In short, South Africa faces some development challenges which it has to deal with while at the same time addressing the problem of climate change.

Strategies to respond to these climate changes have to address these development challenges of poverty, inequality and rural underdevelopment, among others. The climate compatible development (CCD) approach seems to present an appropriate framework for a country like South Africa, which is battling with the twin challenges of climate change as well as development problems as indicated above. Mitchell and Maxwell (2010, 1) define climate compatible development as “development that minimises the harm caused by climate impacts, while maximising the many human development opportunities presented by a low emissions, more resilient, future”. They contend that it is more than a technocratic issue in that it is about transforming development pathways to face the climate problem head on. This chapter explores the extent to which the country has integrated climate considerations into its development planning and management processes. It assesses how responses to climate change also address the development challenges of poverty, unemployment and inequality.

South Africa's response to climate change appears to be quite comprehensive. The Republic of South Africa (RSA) National Climate Change Response Green Paper. General Notice 1083 of 2010, was one of the first major policy responses initiated by the government after it participated in various international fora and dialogues on the risks posed by climate change. The paper recognised that climate change was a threat to South Africa's development and that the government had to respond. It called for the integration of climate change into the nation's planning

processes at all levels. The Department of Environmental Affairs (DEA) was appointed as the lead agency to coordinate climate compatible planning. Based on the Climate Change Response White Paper, the DEA subsequently developed the National Strategy for Sustainable Development (NSSD) Phase I (2011–2014) and the Integrated Resource Plan 2010–2030 (DoE 2011). The government has committed to reducing greenhouse gas emissions by 34 per cent by 2020 and 42 per cent by 2025 (DEA 2013). Other key government agencies also used the Republic of South Africa National Climate Change Response Green Paper, General Notice 1083 of 2010, to develop their climate strategies. For example, the National Treasury, in 2006, introduced its Climate Change Response Strategy Framework for Environmental Fiscal Reform. The Department of Trade and Industry (DTI) has developed the Industrial Policy Action Plan (IPAP) which is a roadmap for South Africa's industrialisation. IPAP includes strategies to promote low-carbon-based industrialisation through green industries (DTI 2012). The Department of Energy (DoE) has been instrumental in developing the 2004 White Paper on Renewable Energy, which sets targets for production of renewable energy. It has since amended and also introduced legislation in order to enhance energy efficiency and also promote the country's transition to a low-carbon economy. The National Development Plan (NDP), which is the country's long-term development vision to 2030, attempts to integrate climate change issues into planning. It has specific strategies for the country's transition from high to low-carbon energy sources, reduction of carbon emissions (for example, the planned introduction of a carbon tax), increasing the supply of renewable energy sources and a range of other ways to protect natural assets. Job creation is also an important developmental target which is addressed by the plan. National, provincial and local governments have been mandated to use the NDP and NSSD frameworks to integrate climate compatible development into their development plans. Most provincial governments have now developed green economy strategies. Local government or municipalities have (some are in the process), also developed similar strategies and used their Integrated Development Plans (IDPs) to implement them.

The government has also set up a Green Fund managed by the DEA and the Development Bank of Southern Africa (DBSA). It provides finance for renewable energy production and other green economy initiatives. The Industrial Development Corporation (IDC) is a government agency which provides finance for industrial development and it is also supporting mitigation activities in industrial development IDC (2011).

1.2. Problem Statement

As argued in the introduction, climate change poses a serious challenge to South Africa. The problem is multi-dimensional in that on the one hand, it is actually acknowledged that the country is one of the major contributors to the high carbon emissions which are known to lead to climate change.

That calls for drastic measures to curb the growth of those emissions. On the other hand, the country must deal with the many negative social, economic and developmental impacts arising from climate change. Succeeding in solving such problems inevitably requires a long-term, sustainable and developmental approach. A comprehensive approach which is embodied in the framework of climate compatible development would be an appropriate intervention primarily because it advocates the integration of climate responses into development planning and management. The fundamental challenge facing South Africa is that although the government has done some commendable work with respect to the development of policies and strategies to deal with climate change, those responses tend to be biased more towards short-term mitigation and are less elaborate and effective with regard to building the much-needed climate resilience within the context of long-term sustainable development. An added challenge is that despite the fairly comprehensive climate-oriented development plans which are integrated into the plans of different spheres of government, implementation has not been equally comprehensive.

The chapter aims to review the plans and strategies introduced by the RSA in order to promote climate compatible development. Its specific objectives are:

- i. to review the country's vulnerability to climate change;
- ii. to describe government's responses to climate change;
- iii. to assess whether development planning has integrated climate responses in the context of climate compatible development; and
- iv. to recommend appropriate interventions in order to enhance capacity to achieve CCD goals.

1.3. Methodology

The paper is based on a review of secondary data. It is a qualitative study. The rationale selection of that methodology was based on the recognition that in order to assess the extent to which South Africa was integrating climate compatible development in its planning strategies and investments, it was important to understand, from a qualitative perspective, the impact of climate change on the country and how it has subsequently responded through various policies and strategies. The purpose of the study was to understand the relationship with each other of the country's climate change challenges and to track in detail, how the RSA has responded at national, provincial and local government levels. In particular, the interest was to assess the extent to which the developmental dimension is integrated within climate change plans and strategies. Sources of data included various reports from key government ministries and departments which are closely involved in the development of national and provincial plans and also those involved in implementing climate policies. The National Planning Commission (NPC) in the Presidency was instrumental in the development of the National Development Plan and so it was one of the main sources of

information. The NDP itself has elaborate discussions on how the government plans to deal with climate change; and so, it was one of the important background documents used. The DEA plays a coordinating role in guiding the public sector on climate change responses and in fact, has developed a National Strategy for Sustainable Development (NSSD) which has informed the rest of government and non-government actors in their responses. Several of the annual reports as well as other reports of the DEA were used in the study. One of the key reports used for the paper is South Africa's 1st Biennial Update Report 2014 which was produced by the DEA. This was part of the inventory for 2000–2010 which the country prepared for the United Nations Framework Convention against Climate Change (UNFCCC). This is a very reliable source of data as the inventory was calculated using the principles of the 2007 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (DEA 2014, vi).

Reports by other government departments, for example, the Department of Energy (DoE) were also used because that department is pivotal to the country's mitigation activities, such as the drive towards a low carbon economy through development of renewable energies and also the efforts to improve energy efficiency. Most of these reports are credible because the government usually contracts reputable academic and research institutions to prepare them. For example, the Universities of Cape Town and Stellenbosch have undertaken most of the research which informed those reports. Available published sources such as journals were also reviewed and used as credible sources of information. Most of the information which was analysed in the sources referred to above included, but was not limited to, the following:

- i. the impact of climate change on South Africa; meant to provide a background to CDD;
- ii. national policy responses to climate change — an exploration of how national development planning has responded to climate change. Consequently, this called for an extensive review of the NDP and various other national level strategic responses.
- iii. provincial level responses to climate change; and
- iv. local government responses to climate change. This focused on responses by metropolitan municipalities as well as district and local municipalities. It explored how IDPs reflect climate change plans and actions.

As expected in qualitative research, analysis is based on emerging themes. In this instance, the author identified a number of themes which were relevant to linking CCD to South Africa's national, provincial and local level planning processes and investment initiatives.

1.4. Organisation of the Chapter

This chapter is divided into four sections. Section 2 describes the theoretical framework which informs the analysis. Section 3 presents and analyses evidence from literature. Section 4 concludes the chapter and makes recommendations.

2. Theoretical Framework

The concept of CCD provides the theoretical framework for the paper. The goals of CCD can only be achieved through a comprehensive and integrated development planning approach which integrates climate resilience mostly in the form of mitigation and adaptation. Planning also has to identify the various opportunities from climate responses and develop implementable strategies that enhance sustainable and inclusive development goals. Mitchell and Maxwell (2010, 5) propose that in order to achieve climate compatible development, policy makers need to develop national and sub-national governance systems, including legislative, institutional architecture, regulatory and accountability measures, that can:

- take advantage of combining efforts to lower emissions or keep emissions low, build resilience, grow and develop; and
- integrate measures to build resilience and reduce risk into development and low emissions growth strategies at all scales;
- ensure that transitions to resilient low emissions growth have significant benefits for poor people; and
- acknowledge and plan for the threats and opportunities associated with a new international, climate-related development landscape.

Planning can be viewed as a systematic process of developing strategic actions in order to resolve a particular problem. In the context of CCD, planning has to integrate mitigation and adaptation strategies which are designed to address the risks and vulnerabilities which communities, sectors and institutions experience in the face of climate change. UNEP (2011) proposes that planning for climate change within a developmental context must critically focus on mitigation and adaptation. Climate adaptation tends to be delivered through four main routes: 1) reductions in existing vulnerabilities to past and present stressors, 2) building adaptive capacity, 3) risk management to address current and future risks, and building long-term resilience to climate change. Mitigation activities can be broadly grouped into five main areas: 1) efficient use of energy (i.e. reducing system waste); 2) using renewable energy sources, such as solar, biofuels, wind, ocean thermal exchange; 3) carbon sequestration through enhanced sinks (e.g. reforestation, afforestation); 4) reduced sources of emissions through land use management; and 5) macro-engineered carbon capture and storage (Tompkins *et al.* 2013). Adaptations most often occur locally and reactively in response to real or perceived climate threats. At

the national level, adaptation is frequently driven by government action (Tompkins *et al.* 2010), and most often focuses on reducing existing vulnerabilities or building adaptive capacity (Tompkins *et al.* 2013). Bulkeley *et al.* (2015) advocate what they refer to as a multi-level governance framework which emphasises the importance of an integrated and coordinated approach among different levels of government. They view multilevel governance as a flexible conceptual framework which can be used to understand the relationships between cities, regions and national governments across mitigation and adaptation policy issues as well as across a widening range of non-state and non-governmental actors. They emphasise that:

Attempting to understand the political economy of climate change policy using a multilevel governance approach helps to break down a state-centric understanding and to better characterise the relationships between different actors horizontally across and vertically between different levels of government (Bulkeley *et al.* 2015).

According to them, the vertical dimension of multilevel governance acknowledges that national governments cannot effectively implement national climate strategies without working closely with regional and local governments as agents of change. Cities on the other hand, cannot be effective and do not operate in isolation from other parts of government. Local governmental authority to act in areas related to climate change is often “nested” in legal and institutional frameworks at higher scales (Bulkeley *et al.* 2015). The horizontal axis represents the role of multi-level patterns of governance which are all central to the success of climate change responses.

The multi-level governance framework which is advocated by the authors as described above emphasises that effective climate compatible development cannot be successfully achieved without adopting a more holistic approach which recognises the important role that different levels of government and institutions have to play. Thus, in any country where climate change is an issue, planning has to be an integrated process which involves all government departments and also one which has mechanisms for engaging other important stakeholders outside government, for example, business, communities, civil societies and so on. Kehewa *et al.* (2013) also emphasise the importance of understanding climate governance from a multi-level perspective and effective approaches require integrated action at multiple levels of government and within the spheres of politics, economics, and society. Within such a framework, national, state, and local governments have distinct and complementary roles to play.

An integral part of climate compatible planning is building resilience and reducing vulnerability. Citing the Intergovernmental Panel on Climate Change, UNDP (2014, 16), defines resilience as the “ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner.”

They also define a related concept, *social resilience* as the capacity of individuals or groups to secure favourable outcomes under new circumstances and, if need be, by new means. The report advocates a human development approach to resilience and defines it as one that focuses on people and their interactions; that resilience is to be built at the level of both individuals and society in terms of their individual capabilities and social competences.

Clapp, Briner and Karousakis (2010) emphasise the importance of integrated planning in the design, implementation and monitoring of climate change policies. The integration has to be in terms of multi-stakeholder engagement — inter-ministerial and/or inter-departmental, inter-sectoral, multi-disciplinary and multi-institutional approach. To illustrate the centrality of an integrated approach, suppose that in order to reduce carbon emissions, a government decides to introduce a carbon tax. In order to reduce demand for fossil-fuels, it could consider increasing such a tax. But it is inconceivable that one government department (for example, Treasury in the case of South Africa), could design and implement such a measure single-handed. Other stakeholders will be affected either positively or negatively. Producers of renewable energies are likely to be positively affected as demand for energy sources may shift from fossils to renewables (a lot depends on relative elasticity of demand for both products). Private sector as well as the general public are likely to be hurt by the introduction of carbon tax (through higher costs), but they should also benefit from the positive impact on production of renewable energies—which also depends on other factors such as the initial costs of investment in renewables, technology availability and pricing of those energy sources. From a CCD perspective, the interest will be on the developmental impact of the tax, for example, if it leads to a shift from fossil to renewable energies, and how the population benefits. What jobs are created and how decent are they? How do local communities benefit? Does the production of those alternative energy sources contribute towards improved livelihoods of communities around them or not? In essence, introduction of a carbon tax would require the ministries or departments responsible for taxation to engage other ministries, business/industry, consumers at large (the public and suppliers) and also development practitioners/organisations. That is the integration which is necessary in a CCD context. Integration therefore also demands that poverty reduction, wealth-creation and livelihoods of communities be improved in the course of mitigation and adaptation to climate change. Integration also requires that CCD strategies and planned actions are included in the budget processes and the monitoring systems thereof; otherwise the risk of failure in terms of implementation is high. It is also argued that when CCD programmes are cast within the framework of poverty reduction and economic growth, they are more likely to be integrated into planning processes and receive allocation of funding.

The success of any planning system also critically depends on the building of a diverse set of institutions that are adequately resourced in terms of

budgetary, human and information resources. Because climate change impacts cut across various stakeholders, sectors and institutions, it is important to have planning institutions which have the requisite systems and processes for inter-agency coordination and engagement. Even if the planning role is anchored in the public sector, there should be mechanisms for effective communication, consultations and engagement with the private sector, civil society and other relevant stakeholders. In most countries, although ministries related to the environment tend to be the lead agency for climate resilient planning, every single ministry and department at all levels has to integrate climate-related issues in their plans. In essence, planning for CCD requires comprehensive institutional structures and systems in order to develop appropriate and effective strategies for the twin goals of responding to climate change whilst also advancing social, economic and human development.

One of the countries which has been very vulnerable to climate change is Bangladesh. That has led to widespread awareness about the inter-relationship of climate change and development, and the dangers that climate change poses for its economic growth. It is not therefore surprising that it is among those countries which have developed comprehensive response strategies within the context of climate compatible development. With support from the UNDP and the UNEP, the government has developed strategies which integrate climate change challenges and opportunities into the overall development plan and programs involving all sectors and processes for economic and social development (People's Republic of Bangladesh 2011, 45–46).

3. Review of the Evidence on Responses to Climate Change

This section reviews the nature of the government's responses to climate change and how this cascades throughout the different spheres of government. Particular attention is paid to how the planning processes have integrated climate compatible development within the context of CCD. South Africa's approach to CCD is based on a realisation that because climate change cuts across practically all government departments and the different spheres of government, it is important to adopt a coordinated and integrated approach to climate change responses. As discussed earlier, there is hardly any sector which is not vulnerable to climate change.

The National Climate Change Response White Paper was one of the first policy responses to be developed by the government and it essentially accepted that climate change was a risk to the country and that appropriate intervention measures had to be developed and implemented by the government.

3.1. Climate Change Frameworks within the Context of Development Planning

South Africa's 2011 National Climate Change Response White Paper is the first coherent outline of national government's responsibilities relating to mitigation and adaptation. The strategy adopts a strongly sectoral approach, but also identifies the need for coordination of responses between sectors. Although many adaptation options are suggested across sectors, fewer examples exist of a move beyond coping with current variability to adapt to climate change in practice (Ziervogel *et al.* 2014).

South Africa's 2011 national policy position on climate change emphasises that socio-economic risks resulting from a range of emission scenarios need to be better understood and quantified in order to inform planning and practice. In an effort to address the problem, in 2013, the National Department of Environmental Affairs commissioned the Long-Term Adaptation Scenarios (LTAS) project. The objectives of LTAS are to develop national and sub-national adaptation scenarios under a range of plausible future climate conditions and development pathways, so as to enable the incorporation of 'climate resilience' in future development planning. In response to the climate change challenge, South Africa has developed a number of strategies and policies which are currently being implemented. The NDP is a national vision for the country's development to 2030. It is national strategy which is designed to find solutions to the many challenges which the country inherited from its apartheid legacy. Those challenges include high unemployment rates, inequality in terms of ownership and access to productive resources such as land, inadequate provision of infrastructure particularly in more remote rural communities, a low and stagnant rate of growth in recent years and poverty at large. The main thrust of the plan is to stimulate economic growth and development. Achieving development is a top priority as reflected in the following paragraph:

The national plan has to attack the blight of poverty and exclusion, and nurture economic growth at the same time, creating a virtuous cycle of expanding opportunities, building capabilities, reducing poverty, involving communities in their own development, all leading to rising living standards' (NPC 2011, 179–192).

The statement makes it evident that the government places great importance to stimulating economic growth as a strategy to reduce poverty and achieve human development. The government's commitment to poverty reduction is demonstrated in the inclusion, in the measurement of the Plan's success, of the degree to which the lives and opportunities of the poorest South Africans are transformed and the extent to which that is achieved in a sustainable manner. The Plan has a comprehensive strategy for job creation and the improvement of livelihoods. Its commitment to the goal of climate compatible development (though this terminology is not used in the plan), is, however, evident in Chapter 5 which is devoted to the

articulation of strategies towards the nation's transition to a low-carbon economy. The chapter sets out specific targets to achieve that goal by 2030. They include the reduction of greenhouse gas emissions, introduction of an economy-wide carbon price and zero emission standards to be reached, installation of 5 million solar water heaters, and production of at least 20,000 megawatts of renewable energy (NPC 2011, 20–32). The Commission proposes a number of actions, such as introducing a carbon price, introducing vehicle emission standards, supporting the development of renewable energies, introduction of a carbon tax in order to enhance energy efficiency and reduce carbon emissions, and requiring all new buildings to meet the energy-efficiency criteria to be set by the government (NPC 2011, 32).

In order to deal with the shortage of electricity facing the country, the NDP proposes to increase the production of renewable energy by 20,000 megawatts, increase the import of hydroelectric power, increase the production of solar water heaters, and support the emergence and growth of Independent Power Producers (IPPs) in the co-generation of electricity. Eskom, the national power utility currently has a monopoly, accounting for 95% of the country's production of electricity (www.reeplo.com 26/04/2015). The plan also aims to increase the coverage of electricity to 90% by 2020 and 95% by 2030 (NPC 2011, 31). The rationale is that if more people can use electricity for their lighting and cooking, this will help to reduce the reliance on wood fuel and the deforestation which this inevitably results in.

The NDP provides detailed proposals for adaptation to climate change. A few proposals made in NPC (2011, 179) are:

- i. decreasing poverty and inequality;
- ii. increasing levels of education;
- iii. improving health care;
- iv. creating employment;
- v. developing skills;
- vi. protecting and improving the management of the country's ecosystems;
- vii. increasing investments in new adaptive technologies and techniques in the water, biodiversity, fisheries, forestry and agricultural sectors;
- viii. developing early warning systems in critical sectors, such as agriculture;
- ix. improving or strengthening disaster management systems so as to improve resilience of communities to climate change; and
- x. increasing investments in the conservation, rehabilitation and restoration of natural ecosystems.

In regard to mitigation against climate change, the NDP also makes concrete proposals. The plan notes with concern, the country's continued

reliance on high carbon emitting fossil fuels largely because of its abundant coal reserves. The high demand for electricity at a time when the country has not made significant progress in producing cleaner alternative energy sources accounts for South Africa's continued heavy dependence on coal to produce its electricity even though there is clear recognition of the negative impacts on climate change. However, the country has made some long-term plans towards transitioning from a high to low carbon economy. Under the Long-Term Mitigation Scenarios (LTMS), it has committed to progressive measures to achieve that goal.

It is evident from the above summary of the provisions of the NDP that it presents some detailed strategies on mitigation against climate change. However, although it lists several development problems facing the country, its articulation of adaptation strategies is inadequate. It does not make it clear how CCD objectives can be achieved through the planning process.

Evidence of planning for CCD is reflected in the Integrated Resource Plan (2010–2030), which integrates developmental goals in the transition to a low carbon economy. The IRP observes that the transition to a low-carbon economy will inevitably result in job losses and the loss of livelihoods for millions of employees who are currently working in the high carbon sectors, such as transport, mining and manufacturing industries. Consequently, it will be necessary for the government to intervene by providing alternative employment in public work programmes, for example, the Working for Water, Working for Fire and the programme for uprooting alien plants, among others (NPC 2011, 183). These initiatives have been shown to generate many jobs. However, the NDP does not provide details of how and where these projects will work and what the employment targets are, what it will cost the government, the expected impact on poverty reduction and improvement of livelihoods. Yet, these are the essences of what CCD is all about.

Detailed proposals are made on how mitigation against climate change can be achieved in the areas of water management, food security, waste management, land utilisation, economic growth, and ecosystems management. The NDP also envisages a carbon budgeting system as well as a carbon pricing mechanism, all of which are designed to lower the carbon footprint.

The LTMS referred to above emphasise that it will not be possible for the country to achieve its goal of a low-carbon economy within the current framework of an economic structure which is centred on energy and carbon-intensive activities. It argues that structural transformation of the economy will be necessary and that it will require some technological and infrastructural innovation and development. Government investments in education and building and enhancing capacity for climate planning and implementation will be key drivers for change. The NDP underscores the critical importance of 'how to de-link economic activity from carbon-

intensive energy while remaining competitive and reducing unemployment, poverty and inequality' (NPC 2011, 186–187).

In order to ensure implementation of the proposals on mitigation and adaptation, the NDP stipulates that budgets should be aligned to those goals. Domestic resources in the form of carbon pricing should be mobilised to finance the planned activities. The plan also called for the creation of a Green Fund which would finance the development of clean energy sources. It calls for public investments in low-carbon technology, infrastructure and businesses (NPC 2011, 190).

The picture that emerges from a reading of the NDP is that of a government which understands the threat of climate change and commits itself to developing comprehensive responses in the form of strategies and policies. The document also demonstrates an understanding of the fundamental importance of integrating climate responses to social, economic, and human development. This is particularly apparent in the plan's description of the guiding principles for the transition to a low-carbon economy. The principles begin by pointing out that human well-being is dependent on the well-being of the environment, and hence, in planning for responses to climate change, it is necessary to integrate social, economic and environmental considerations and to seek, explore and exploit the many opportunities which may arise and use them to advance human development. This is at the centre of CCD, and so, in this regard, the NDP essentially plans for CCD. Among other things, the guiding principles emphasise that the transition must be just, ethical, and sustainable; evidence-based; transformative; comprehensive; holistic in terms of integrating social, economic and environmental concerns; opportunity-focused; and consultative in relation to the many stakeholders involved in national climate issues. Equally important, the principles call for sound policy management and strategic planning and that government at all levels has to adopt and apply a systems perspective which recognises the complexity of developing and implementing a comprehensive planning process which aims at minimising the adverse impacts of climate change while trying to maximise the developmental opportunities and benefits which arise in the process.

As a national development framework, the NDP provides a clear framework for CCD. Its implementation is the responsibility of the different national, provincial and local government spheres of government as well as communities. An assessment of what South Africa has achieved in terms of the NDP strategies on CCD can only be made by examining how the different spheres of government have integrated those strategies into their own planning processes; how they are implementing them; and what successes they have made to date. The assessment will review the various policies and legislation which have been developed in response to climate change. Some of these were actually in place even before the NDP

was developed. It will also give examples of how different spheres of government as well as non-government actors have responded.

3.2. Role of Government Departments

The DEA is the lead department for climate change.

The National Planning Commission has to ensure that its long-term vision is climate resilient because its mission is to “improve government performance in achieving desired outcomes and to improve service delivery through changing the way government works” the Department of Performance Monitoring and Evaluation (RSA 2002)).

There is a realisation that no one department can take full responsibility to planning for climate change. The Department of Agriculture has to address the negative impacts of climate change on agriculture and food production because it has been noted that temperature changes, changing rainfall patterns, droughts and floods all require adaptation measures. Agriculture also emits GHGs and mitigation measures are therefore necessary. The Department of Cooperative Governance and Traditional Affairs has oversight on local government and therefore has to ensure that they integrate climate change in their IDPs. The Department of Economic Development also has to green its strategies because they are also affected by climate change. Many strategies which are designed to increase economic growth (through, for example, infrastructure development, industrial development, agricultural growth and processing) are related to climate change. The Department of Energy has to address the reality that the country’s energy sources are largely responsible for the high carbon emissions which contribute to global warming and climate change. It also has to take responsibility for the development of cleaner energy sources. This is indicated in its vision and mission (DoE 2014).

The National Treasury which is responsible for fiscal and budget implementation also plays an important role. By using carbon taxes and trade measures, it can influence the transition from high-carbon to low-carbon economic growth and development. Its decisions on budgets can shape the implementation of mitigation and adaptation measures. Departments responsible for mining and other resource sectors also have a responsibility to adopt measures to reduce the carbon emissions from those sectors and to promote the development of alternative energy sources. The Department of Science and Technology plays an important role in promoting innovations and research on technologies for climate resilience and carbon emission reduction. The Department of Education is pivotal in raising awareness on climate change. The Department of Human Settlements is key in ensuring that housing and the built environment are resource-efficient and climate-resilient. The Department of Public Works plays a key role in creating jobs through implementation of public programmes which address climate change impacts on biodiversity, land, and water, among others. Its programmes on Working for Water, Working

for Fire, for example, have created many green jobs (DEA 2013, 33–34). The government has established the Inter-Ministerial Committee on Climate Change (IMCCC): in September 2009 consists of six ministers: Water and Environmental Affairs, International Relations and Cooperation, Economic Development, Trade and Industry, Rural Development, and Cooperative Governance and Traditional Affairs. The IMCCC ought “to direct the formulation of a national programme for climate change, and to develop South Africa’s final mandate for the UNFCCC” (GCIS 2009). According to the Green Paper, the IMCCC “shall exercise oversight over all aspects of the implementation of [climate] policy” (DEA 2014: 33). National, provincial and local government in South Africa as well as the private or business sectors, have, to a large extent, achieved a measure of success in integrating into their own plans, the CCD goals which are articulated in the NDP. Examples of a few key departments which are central to climate change issues are reviewed in order to demonstrate this. There is evidence of some detailed strategic plans at the different levels. However, implementation in many instances appears recent and achievements appear to be quite limited as a result (Author’s observation based on review of performance reports of departments).

The National Department of Environmental Affairs (DEA) has been tasked by the government to coordinate the nation’s responses to climate change. One of its first projects was to develop the National Strategy for Sustainable Development (NSSD). The strategy creates the framework for government ministries and departments at all levels to develop systems for integrated planning and their implementation. It also seeks to promote ecosystems and efficient use of national resources, the building of a green economy, creation of sustainable communities, building capacity of government to empower them. The NSSD also aims at achieving effective responses to climate change (DEA 2011, 14). Under the goal of sustaining ecosystems and using natural resources efficiently, the DEA has proposed several strategies which relate to the water, marine resources, biodiversity and ecosystems, water and air quality, among others and these are to guide the rest of government departments to integrate them into their strategic plans and budgets. Under the green economy agenda, the DEA provides guidelines for clean energy and energy efficiency, sustainable consumption and production, environmental sustainability, sustainable waste management and resource conservation and management. The NSSD is supposed to provide a more detailed framework for climate response and sustainable development and be the basis for government, business, labour, and communities to implement development activities in the context of climate change. In 2011, the DEA popularised the strategy when it held a summit, now popularly referred to as the Green Accord. This was a social compact between government, business and civil society to commit themselves to the goal of sustainable development.

It is difficult to conclude on the success or failure of the NSSD because it is a recent framework whose implementation is also quite recent. It is a fairly

comprehensive document which builds on the White Paper on the National Response to Climate Change of 2004. It has raised awareness within and outside government on the need to formalise and internalise climate change responses into government plans and actions at all levels. This appears to be happening as the annual reports of many departments show. For example, a review of the annual reports of the Departments of Trade and Industry, Provincial Departments of Public Works, Economic Development, Environment and Tourism, Health and Social Development, while reflecting many planned climate change activities, do not show evidence of implementation.

Evidence gathered from other departments shows that significant progress has been made in terms of introducing new policies and regulations or amending existing ones in order to adequately respond to climate change based on the NDP proposals for the transition towards a low-carbon economy. One of the departments which is at the centre of significant change is the Department of Energy (DoE) which was established in 2009 following a Cabinet decision to restructure the former Department of Minerals and Energy (DME). Recognising the urgency of increasing the country's energy supplies and also the challenge of climate change, the government tasked the Department to develop and implement strategies to ensure adequate energy provision which includes clean and renewable resources (DoE 2009, 10).

A review of the climate-related policy developments made by the DoE demonstrates the cascading of national policy (from NDP) to national and provincial government departments. Once again, it appears that while there has been comprehensive policy development on energy, implementation to date is still limited mainly because most of the changes are fairly recent. It was also observed that the policy regime is very strong on mitigation. However, adaptation seems to be less emphasised and consequently, the goal of CCD seems to be less feasible because of its apparent 'diminished' focus at the level of departments. The overriding concern appears to be the imperative to reduce carbon emissions and to promote development of alternative and clean energy sources. How does one explain this? One of the reasons could be the dominance of government in the design and implementation of climate response strategies to a level where communities are essentially excluded, not so much by design but by government's own intense 'preoccupation', if not 'obsession', with planning processes while being oblivious to the imperative to include and engage communities. Local governments are tasked with that function when they develop their IDPs and municipalities are actually supposed to ensure that communities participate meaningfully in the IDP processes but in practice, this has been limited as various studies show.

The Department of Energy (DoE) was established in 2009 and was tasked with ensuring the security of energy supplies and for achieving an energy mix which includes clean and renewable energy resources (DoE 2014). The

Department was created following the restructuring of the former Department of Minerals and Energy (DME).

In order to implement its mandate, the DoE developed a 5 year Strategic Plan which centres on energy security, economic growth, environmental sustainability and increasing energy access. It is a very detailed strategy which combines elements of climate change mitigation as well as adaptation. The following are examples of what the Department has done (DoE, 2014, 11) in order to advance the goal of mitigation.

- i. Integrated Resource Plan 2010 was introduced. The Plan sets out South Africa's energy sector on a low carbon trajectory.
- ii. Integrated Energy Plan (IEP) for the development of energy infrastructure was introduced.
- iii. New legislation has been introduced to deal with the electricity shortage and the imperative to achieve a low-carbon economy in the long-term. The National Energy Act, 2008 (Act No. 34 of 2008) makes provision for the diversification of energy resources and also for their use in reducing poverty. It mandates the DoE to support increased generation and consumption of renewable energy.
- iv. Some existing legislation have been amended in order to align them to the national goal of moving towards a low-carbon economy. For example, the Electricity Regulation Act, 2006 (Act no 4 of 2006) allows for co-generation of electricity so that renewable suppliers can also supply power to the national electricity grid. The Act also empowers the Minister of Energy to establish Independent Power Producers (IPPs) in order to increase supply of energy.
- v. The DoE has also submitted a proposal for a regulatory framework for mandatory blending of biofuels. The draft is under discussion by various players in government, business and the public sectors (DoE 2014, 18).
- vi. The Department has been instrumental in developing standards for a Cleaner Fuels Programme where it has set fuel specification standards for reduction of harmful emissions. These are aligned to global technology trends and environmental requirements. They are expected to come into effect in 2017.
- vii. Implementation of a massive Infrastructure Investment Programme called the Renewable Energy Independent Power Producer Programme (REIPPP). The Programme aims to increase South Africa's energy generation capacity using low carbon sources. The DoE plans that the Programme should generate about 40,000 MW of energy, out of which 17,900 MW will be from renewable energy, 2,600 MW from imported hydropower, and 9,600 MW from nuclear energy.
- viii. The IPP represents a shift from the Renewable Energy Fit in Tariff (REFIT) to a more competitive bidding process based on certain

criteria. REIPPP seeks to promote solar, wind, hydro, biomass and landfill-based sources of energy. Under the REIPPP, the DoE has contracted about 47 projects in solar and wind mainly in the Northern and Western Cape Provinces.

- ix. The Department has been instrumental in the roll-out of the Solar Water Heaters (SWHs) Programme and has prescribed a minimum local content level of 70%. It has mandated the South African Bureau of Standards to check and verify compliance when bidders apply for contracts.
- x. Increase access to electricity to those households which do not yet have electricity services. This will reduce dependence on firewood for cooking and lighting and therefore also reduce the carbon footprint and curb deforestation. Access to electricity in South Africa has increased from 36% in 1994 to 86% in 2013 (DoE 2014, 13). The government has pledged to achieve 100% access by 2025. The Integrated National Electrification Programme (INEP) is the instrument which the Department will use in order to achieve that goal. An important feature of the INEP is the integration of a social protection component. Through the Free Basic Electricity (FBE) Policy, the government has increased access to electricity to indigent communities (DoE 2014, 13). The government has increased its budgetary allocations to the INEP from R2.6 billion in 2009/10 to R4.1 billion over the 2013/2014 financial year (DoE 2014, 13).
- xi. In partnership with PetroSA, the government has introduced Integrated Energy Centres (IeCs) in remote rural areas. These sell illuminated paraffin, liquefied petroleum gas (LPG), petrol and diesel at affordable prices.
- xii. To develop nuclear energy for peaceful uses, it has set up the South African Nuclear Energy Corporation (NECSA) Visitor Centre in order to provide information and awareness on the programme.
- xiii. The DoE was instrumental in the establishment of the South African National Energy Development Institute (SANEDI). It is regulated under Section 7(1) of the National Energy Act, 2008 (Act No 34 of 2000). SANEDI receives a government grant of R34, 3 million over the 2013/2014 financial year (DoE 2014, 51).

The evidence shows that various government departments at national and provincial levels are involved in formulating and implementing climate plans within the context of the country's development framework. Through the National Planning Commission (NPC), the national government was instrumental in the development of the NDP which presents the long-term development strategy for the country. As indicated, the NDP provides a detailed framework for responding to climate change and also articulates the development challenges facing South Africa. Other government departments responsible for implementation should then develop their own plans within that overarching framework. Evidence shows that, to a large

extent, most, if not all, government ministries and departments have responded positively by integrating the climate change agenda into their plans. However, it clearly appears that mitigation objectives override adaptation and other developmental objectives.

Although at the level of policies and strategies DoE appears to have comprehensive strategies, they are mostly on mitigation. Furthermore, some of the policies are contradictory to the low-carbon economy agenda; for example, the massive investment in the coal-fired power stations at Medupi and Kusile. While the efforts to promote investments in renewable energy are commendable, the energy generated is far below what is required for the transition to a low-carbon economy and it means that much more has to be done in terms of implementing strategies for the transition.

The failure to integrate developmental goals in climate planning is a major weakness of the plans. Although there is much emphasis on job creation in NDP, the New Growth Path (NGP), 2010 and IPAP, to date, performance on job creation has not yielded expected results due to the slow implementation of the plans.

A review of South Africa's 1st Biennial Update Report of 2014, which is one of the most reliable climate change progress reports submitted to the UNFCCC, reveals a number of issues regarding the country's performance to date. Firstly, it shows that climate plan implementation has tended to be more into mitigation rather than adaptation activities. That is because of the overriding concern over the high carbon nature of production and consumption across the economy. See for example DEA (2014, 106, 110, 119).

Even the external grant assistance has largely been for mitigation-related activities. Secondly, much of the mitigation activities focus on enhancing energy efficiency and also, to some extent, towards development of renewable energy alternatives to fossil fuels. Thirdly, adaptation programmes are more limited in scope as well as funding support from external agencies. Fourthly, there is evidence of integrating climate change into municipal planning through the 'Let's Respond Toolkit'. This is a toolkit for integrating climate change risks and opportunities into municipal planning. It was designed to assist local government with mainstreaming climate change issues into their planning process. Whether or not they are already using such a kit was not evident from their IDPs; but this is something which could be implemented in future.

For example, the German government gave the government a loan of USD 54,083,000 towards the Green Energy Efficient Fund of the Industrial Development Corporation. This Fund offers private sector companies, particularly small and medium sized enterprises, financing at below-market interest rates to promote investment in renewable energies and energy efficiency (DEA 2014, 89). Germany also advanced a loan of USD 101,405,000 to support the development of solar power in South Africa, in

particular concentrated solar power. Together with the European Investment Bank, African Development Bank (AfDB) and the World Bank, Germany also committed towards supporting construction and commissioning of a 100 MW CSP Power plant in Upington, Northern Cape. The project will be implemented by Eskom on behalf of the South African Government (DEA 2014, 89).

Another loan of USD 45,970,000 was awarded in order to broaden the roll-out of renewable energies and to create jobs in small- and medium-sized enterprises. A grant of USD 100,791,000 was awarded for the Manufacturing Competitiveness Enhancement Programme to the Department of Trade and Industry for energy efficiency and transition to low-carbon economy (*ibid.*).

3.4. Local Level Responses

Ziervogel *et al.* (2014, 614) observes that local governments do not get much financial or technical support from the national level to undertake climate change adaptation. They argue that although national and provincial governments are mandated to address climate change, at municipal level it is contested and regularly referred to as an ‘unfunded mandate’ (Ziervogel *et al.* 2014, 614). Despite those constraints, the authors note that a number of municipalities and metros are integrating adaptation into their plans and practice. A review of the responsiveness of metropolitan municipalities to climate change in South Africa by Moyo (2015), confirms the observations made by Ziervogel because she notes that many metros have developed comprehensive green economy strategies. However, the implementation of those plans to date appears very limited although there are some significant successes. Examples are presented in the section below.

Under its Johannesburg 2040 Strategy, the city has embarked on developing a rapid bus transport system in order to provide reliable, efficient and low-carbon public transport system. One of its most successful infrastructure projects is the *Rea Vaya* (meaning ‘we are going’) bus rapid transport system. The system, based on the Brazilian Curitiba model, utilises specialised vehicles, dedicated bus lanes, easy-access stations, and reliable scheduling. This is an extensive public transport network that offers safe and affordable transport for most of the city. It is integrated with the Gautrain, Metrorail, bus routes, pedestrian corridors, and taxis across Johannesburg. According to the City, the *Rea Vaya* is the single largest climate change initiative ever undertaken by the City and represents a major turning point in how it deals with congestion, pollution and greenhouse gases caused by transportation. The *Rea Vaya* has improved public transportation and also, critically, it has contributed to the reduction of Johannesburg’s public transport carbon footprint (City of Johannesburg 2014/15 Review). It is anticipated that the expansion will allow at least 80% of the residents to use public transport. That will reduce the use of

private vehicles for day-to-day transport and will thus reduce the carbon footprint.

Green Economy Strategy Framework is the establishment of a clean-tech Special Economic Zone (SEZ) in Atlantis, which is being managed by Green Cape (City of Cape Town 2015). The SEZ has strong support from national and provincial government, as well as the City of Cape Town. One of the major initiatives introduced by the City of Cape Town and the Western Cape government's Department of Economic Development and Tourism (DEDT) is the Atlantis Green Technology Park, 40 km north of the city, the heart of green manufacturing in the province. It is designed to increase the development of green technologies particularly renewable energies. Atlantis provides an ideal location for prospective investors. It has good access to roads, well-priced industrial land and access to port facilities. The manufacture of wind turbine towers in the Atlantis Green Manufacturing Hub is part of the Renewable Energy Independent Power Producer Procurement Programme. The wind turbine project is expected to create 200 permanent jobs in the area. Chinese-based Jinko Solar plans to set up a solar panels plant in Cape Town. The expansion of a car manufacturing company is also underway. A total of 700 potential jobs were expected to be created should the enquiries and pending business decisions materialise, including the number of jobs that the GRI investment has brought into Atlantis (City of Cape Town 2015).

The City of Tshwane (formerly Pretoria), has also introduced a bus rapid transit system, the *Are Yeng* (meaning, 'let us go') BRT. This will be rolled-out in phases and will entail the construction of 80 km long dedicated lines (Venter 2013). The BRT is run by a company called Tshwane Rapid Transit (TRT) Pty. Ltd, a corporate entity in terms of the Companies Act 71 of 2008 (City of Tshwane 2014 (<http://www.tshwane.gov.za/.aspx>)). The BRT has interesting sustainability features. The City has engaged former taxi industry owners and invited them to participate as shareholders. That is how they have been integrated into the new system. All the buses used under the BRT system are assembled in South Africa. The buses are also designed to comply with the European emission standards (City of Tshwane 2014).

The City of eThekweni (formerly Durban) also has a BRT. Its R22 billion "Go Durban" Integrated Rapid Public Transport Network (IRPTN) is designed to be universally accessible in the long-term (eThekweni Municipality 2011 Accessed from <http://www.durban.gov.za/> on 23/01/2015).

The City also plans to construct 9 transport corridors linked by various modes of transport (bus, rail, taxi) across eThekweni, by 2027. The main objectives of the project are to improve access to work, and to social facilities, such as educational and health institutions.

In her study on municipal responses to climate change, Mokoena (2009, 12–30) observes that major metropolitan municipalities have developed strategies to deal with climate change. For example, the City of Cape Town introduced its Energy and Climate Change Strategy (2005) and the Framework for Adaptation to Climate Change in the City of Cape Town (2006). It has also developed a long-term vision called “Vision 2020”, which aims to protect natural resources and to maximise their benefits to all residents of the city. As an indication of the city’s commitment to climate change planning, it increased the size of its environmental management department, which grew by approximately twenty (20) people to about 240, spread across a range of activities in conservation and environmental and biodiversity management more broadly (Mokoena 2009, 16).

In the case of eThekweni Municipality, she indicates that the city has produced an array of policy documents and plans to deal with climate issues. One of the objectives in its Integrated Development Plan 2010 and beyond was that “...all citizens, the business community and visitors must have access to economic opportunities ... and a clean and green city” (Mokoena 2009, 16).

Some of the plans are more elaborate regarding developmental issues. The ‘Imagine Durban Project’ is a case in point. The Action Plan proposes to reduce unemployment by 25 per cent in 10 years, and by 50 per cent in 20 years. In 50 years time, Durban aims to secure sustainable livelihoods for its citizens. To achieve these goals, the Action Plan proposes multiple strategies that include enhancing livelihood choices for people living on the urban fringe of the city in impoverished settlements by tailoring policies, especially those concerning service delivery, to support the livelihood choices of poor households (Mokoena 2009, 16). The different spheres of government are meant to support this initiative through the provision of information and training on food production

Mokoena notes that many of the projects which were designed to address climate change were in their infancy, even though Durban initiated a Climate Change Protection Programme in 2004 according to the 2009/2010 IDP Review which she cites. Mokoena’s study also reported that an official within the Municipality had made a comment that there had been very little progress on climate change as a focused policy issue and many of the community-based projects to address climate change were only in the pilot phase (Mokoena 2009, 21).

They also point out that there are institutional barriers for addressing climate change across a range of municipalities and these include a lack of capacity (both in terms of numbers of people and expertise); high turnover of staff within government departments; limited understanding of and expertise in tackling climate-related issues; the positioning of climate change as an environmental issue rather than as a development issue; conservative financial management practices; and poor communication and coordination between departments and between different levels of

government (especially national to local and provincial to local) (Ziervogel *et al.* 2014).

Planning for CCD has not been an easy task for the government. A major challenge is that provincial and local governments have experienced constraints that affect enforcement and implementation of environmental policy countrywide. This highlights the fact that the current institutional structure and the lack of capacity pose a challenge to the delegation and decentralisation of executive environmental functions to the most appropriate level. The main challenge seems to be the deterring influence of implementation failure at local level on the effective functioning of the environmental governance framework (Giodarno *et al.* 2009). The authors also explain that municipalities are already struggling to deal with current delegations on environmental management (Giodarno *et al.* 2009, 23). They also observe that another issue is that climate change is a new issue that is not fully understood and most provinces and municipalities require assistance to develop and implement relevant measures.

3.5. Investments in Renewable Energy

The government set up the Green Fund which is coordinated by the DEA and the Development Bank of Southern Africa (DBSA). Most of its investments have been in renewable energy projects in line with the government's long-term goal of moving from a high- to low-carbon economy. See, for example, DEA 2014, 106–119). The government has been quite successful in initiating some renewable energy investments even though the volumes of energy which they produce are not at a level that can replace the dominant fossil-based energy sources. Some examples of renewable energy investments are cited in the section below.

According to a report by South Africa Information (2015), the Department of Energy is in the process of developing two solar power plants in the Northern Cape. Kathu Solar Park and Redstone Solar Thermal Power Projects have been commissioned to produce solar power using the abundant sunshine resources in the province. The government has supported Kathu and Redstone under its Independent Power Producer Procurement Programme. A consortium led by a company called GDF SUEZ, and comprising the Sishen Iron Ore Company Community Development Trust, Investec Bank, Lereko Metier and Public Investment Corporation, is backing the Kathu Solar Park.

The government, through the Industrial Development Corporation, has entered into a joint venture with a Spanish Company, Abengoa Solar. The solar project is being built in Upington in the Northern Cape. It is said to be Africa's first massive solar initiative. The plant will be on 140 hectares of land. Abengoa Solar owns 51% while IDC owns 49%. Khi Solar One is projected to produce 50 megawatts (MW) of energy and contribute towards emissions reduction by 138,000 metric tonnes a year (accessed from www.southafrica.info, on 08/02/2015). Khi Solar One Renewable Energy

Project in Northern Cape Province (Plate 1) forms part of the Department of Energy's bid to bring 1400MW of wind and solar-based energy online by 2016, for which it has invested R33.8 billion. It is part of the South African government's larger strategy to generate 17,800 MW from renewable energies by 2030. The energy produced will be sold to Eskom to channel it to the national grid.



Plate 1. Khi Solar One Renewable Energy Project in Northern Cape Province

SOURCE: www.southafrica.info Accessed on 8/02/2015

The IDC has partnered with Abengoa on another solar project called KaXu Solar One, a parabolic trough plant located near Pofadder, which is still under construction and is set to come online this year. Covering an area of 1,100 hectares, it will have an output of 100 MW and a storage capacity of three hours. It will also reduce carbon dioxide emissions by 315 000 metric tons. Abengoa said it would create 800 jobs during construction phase and 35 permanent plant operations jobs.

A consortium led by GDF SUEZ, and comprising the Sishen Iron Ore Company Community Development Trust, Investec Bank, Lereko Metier, and Public Investment Corporation, is backing the Kathu Solar Park. It will incorporate parabolic trough technology and will be equipped with a molten-salt storage system that will allow 4.5 hours of thermal energy storage.

The consortium behind the Redstone Solar Thermal Power project is led by SolarReserve, a global developer of utility-scale solar power projects and advanced solar thermal technology, and International Company for Water

and Power Projects (ACWA Power), the Saudi water and power developer, owner and operator. It is projected that Redstone will create more than 800 direct jobs during the construction phase, as well as significant additional jobs related to equipment supply, manufacturing, engineering, transportation and other services. Over 40% of the total project value would be provided by South African suppliers, a portion of which would support black economic empowerment activities (South Africa Information 2015). However, it is not clear how many black entrepreneurs will be beneficiaries. Under the IREPPPP, a number of other projects are being supported. Some of them are in Northern Cape and include the Abengoa of Spain, which is building three projects— 1) the 50 MW Khi Solar One power tower project, 2) the 100 MW KaXu Solar One project, and 3) the Xina project. Another project is the Karoshoek Solar One which is being developed by a consortium comprising Emvelo, the Industrial Development Corporation, ACS Cobra Energia, Public Investment Corporation, Investec and the Karoshoek Community Trust (South Africa Information 2015).

These few projects demonstrate that the government has been successful in initiating renewable energy projects. Much of the success was due to the creation of an environment in which domestic and foreign investors could invest in alternative energy sources. However, the scale of investments is still very low considering that the ultimate goal is to shift South Africa's growth trajectory from a high- to low-carbon economy. In terms of local development, it was also anticipated (notably as stated in the NDP, NSSD, NGP and IPAP strategies), that the renewable energy sector would create thousands of jobs. This does not appear to have materialised because most of the investments are capital-intensive. Participation of Small and Medium-sized enterprises is also limited because of the large initial capital investments required in these renewable energy technologies.

4. Conclusion

This paper sought to investigate South Africa's responses to climate change. It specifically aimed to assess the extent to which the country has managed to integrate climate compatible development policies and strategies into its development planning processes. Using CCD as a theoretical framework, the paper argues that although the government has been very successful in terms of building the institutional framework for CCD and also in integrating climate change issues into the development planning process, much of that success relates more to mitigation against climate change. Much less success has been achieved with respect to the more developmental, climate adaptation and resilience.

One of the major achievements made by the government relates to the development of a robust institutional framework for the integration of climate change into development planning. The paper described in detail the institutional mechanisms which have been established at national, provincial and local government levels. At national level, this is most

evident in the NDP and also in the NSSD under the DEA. National and provincial government departments have integrated climate change considerations into their own planning processes. At provincial level, it was observed that provincial governments are busy integrating the NDP into their own provincial development plans and that climate issues are being taken into account. There is also evidence of integrating climate change into local government planning through the IDPs.

The study found that although there have been successes in terms of institutional and policy development with respect to climate change, there is a bias in favour of climate mitigation. Given the high carbon emissions status of the country, it was important that serious efforts be made towards achieving a low carbon growth production and consumption trajectory. However, from a developmental perspective, that is not adequate. It is equally important to build the necessary climate adaptation and resilience in order to achieve a more sustainable response to climate change. Evidence of less prioritisation of adaptation activities is reflected in the limited extent to which development plans across different spheres of government elaborate adaptation activities and also the limited allocation of resources towards that goal.

As a way forward, the paper makes the following key recommendations:

- a. Government needs to strengthen the adaptation dimension as it integrates climate change into its development planning processes at all levels of government.
- b. Part of the problem appears to be the limited engagement with non-government actors or stakeholders and so, it will be important for the government to develop the necessary and effective institutional mechanisms and processes for broad-based stakeholder consultations and engagement. Those processes should bring on board, labour, community-based organisations and civil society in general, into the discourse on adaptation for climate change. Such a process could improve government's efforts to design more appropriate and effective climate interventions to build resilience.
- c. Government has to invest more resources towards building the required capacity for implementation of the many elaborate plans which have been developed on climate change. Evidence from the literature demonstrated that capacity in terms of knowledge and skills on climate change was still an issue particularly at the local government level who are expected to implement most of the climate-related activities.
- d. Increase the allocation of budgetary and other resources towards climate adaptation.

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CHAPTER NINE

Championing a Green Future through Higher Education: Initiatives of Selected Regional Research Organisations in Africa

Truphena E. Mukuna

1. Introduction

Climate change is one of the most important issues on the global political and economic agenda; yet it has taken at least 20 years to become an international priority. In many ways, this is because climate change was originally communicated as a scientific problem. Complex, confusing, and at times contested scientific information resulted in a slow public and political response to the climate crisis. For many people, climate change is still an abstract concept. Africa as a continent has been found by the Intergovernmental Panel on Climate Change (IPCC) to be one of the most vulnerable to climate change (IPCC 2012). Climate change presents an international challenge of a magnitude not previously encountered. Its impacts have the potential to exacerbate existing tensions and create new ones, which, in turn, have implications for stability and security at a local and international level. Climate change is the biggest challenge our generation is facing and the biggest challenge future generations will have to focus on. An effective response to climate change and its associated bio-physical and socio-economic impacts will, therefore, need to be multifaceted and include multiple actors.

The African continent is particularly vulnerable to impacts of climate change affecting key economic drivers such as water resources, health, agriculture, forestry, wildlife, transport, energy, land and infrastructure, and disaster risk management (Viljoen 2013). The vulnerability of Africa to climate change is exacerbated by a range of multiple stressors that are related to poverty and other development concerns in the region. A number of recent analyses have highlighted that the current window of opportunity for action to keep the global temperature increase to 2°C, or preferably lower (1.5°C), below pre-industrial levels, and to build resilience to current climate variability and projected changes, is rapidly closing.

The Africa Adaptation Gap Report, launched on 17 October 2013, confirms that Africa faces huge financial challenges in adapting to climate change. It outlines the costs faced by the continent if governments fail to close the “emissions gap” between current 2020 emissions reduction pledges and what is needed to keep warming below 2°C. The study assigns a 40-per cent chance that we will inhabit a ‘4°C World’ by 2100, if mitigation efforts are not stepped up from current levels. This is confirmed by the recently completed IPCC Fifth Assessment Working

Group I Report. Due to present and committed climate change caused by past emissions, Africa will already experience adaptation costs in the range of USD 7-15bn per year by 2020. These costs will rise rapidly after 2020, since higher levels of warming result in higher costs and damages (Gaborone Declaration 2013).

Donors are making an increasingly audible call to support climate policies that deliver 'triple wins', i.e. action on climate change adaptation, mitigation, or development that produces additional climate change and development benefits (GDPRD 2011). The concept of 'triple wins' originated in the form of 'climate-smart agriculture': "agriculture that sustainably increases productivity, resilience (adaptation); reduces/removes greenhouse gases (mitigation); and enhances achievement of national food security and development goals" (FAO 2010, ii). Climate resilience, climate smart agriculture, and climate-compatible development (CCD), i.e. a single policy with multiple benefits for climate change adaptation, mitigation, and development. Climate change threatens to reverse development progress, unless concerted efforts are made to make development climate-resilient. There is limited evidence for the theoretical links between adaptation and mitigation (Klein *et al.* 2007).

Before the conceptualisation of 'climate compatible development', let us first understand the concepts 'adaptation' and 'mitigation'. Climate adaptation tends to be delivered through four main routes: reductions in existing vulnerabilities to past and present stressors; building adaptive capacity; risk management to address current and future risks; or building long-term resilience to climate change (Ensor and Berger 2009; McGray *et al.* 2007). Adaptations most often occur locally and reactively in response to real or perceived climate threats (Adger *et al.* 2007). At the national level, adaptation is frequently driven by government action (Tompkins *et al.* 2013) and most often focuses on reducing existing vulnerabilities or building adaptive capacity (McGray *et al.* 2007). Some researchers argue that adaptation and mitigation should be treated separately as they are undertaken by different people at different spatial scales (Tol 2009). Others note that adaptation and mitigation policies should be assessed jointly to identify the optimal policy mix within integrated assessment models (Kane and Shogren 2000); and others highlight that at the individual level, adaptation and mitigation are often undertaken jointly as part of daily risk and resource management (Tompkins *et al.* 2013). Yet, planning and policy making for climate change often take place in the absence of clear guidance on how to assess the conflicts, trade-offs, and synergies between adaptation, mitigation, and development actions.

The Inter-governmental Panel on Climate Change demonstrates that climate change is already undermining development. This means that all development work needs to be readjusted to put climate resilience at its heart: be it in agriculture, cities, water, food, or energy. The aim is to ensure climate-resilient investment. Thus, zero carbon electricity; fuel

shifting in the transport, heating, and industrial sectors; energy efficiency in all sectors, including building, transport, and agriculture; and managing land use to ensure ecosystems are carbon sinks, and not carbon sources. There is a need to create a policy environment that is conducive to blended funding (public and private, a mixture of risk mitigation, grants, loans, equity, etc.) in support of low-carbon, climate-resilient investments. There are real hurdles to fast-tracking climate-related development finance. A GIZ-sponsored workshop recently revealed some of these, including a lack of capacity in developing countries for setting up appropriate mechanisms to handle climate finance, and competition among ministries, and often, lack of a clear mandate for coordination. Countries may also struggle to leap from strategies and concepts to investment-ready, low-carbon, climate-resilient projects.

In tandem with the IPCC requirements, we need to understand what climate-compatible development means. Climate-compatible development is an increasingly used, but still contested, term referring to both the desired outcome of climate change policy and the shape of the policy itself. As a policy goal, CCD describes the conditions that allow a community or nation to bounce back from and prosper in the face of climate stress (Tompkins *et al.* 2013). CCD policies aim to deliver green growth while, at the same time, supporting people's ability to adapt to climate change. To better understand the potential for synergies between adaptation, mitigation, and development, 'climate-compatible development' is development that minimises the harm caused by climate impacts, while maximising the many human development opportunities presented by a low-emissions, more resilient, future. Climate change and responses to it are changing patterns of innovation, trade, production, population distribution, and risk in complex ways. This is creating a new development landscape for policy makers, who need to nurture and sustain economic growth and social development in the face of multiple threats and uncertainties while also cutting emissions or keeping them low.

In tackling the challenges, climate-compatible development moves beyond the traditional separation of adaptation, mitigation, and development strategies. Instead, it emphasises climate strategies that embrace development goals and development strategies that integrate the threats and opportunities of a changing climate. As a result, it heralds a new generation of development processes that safeguard development from climate impacts (climate -resilient development) and reduce or keep emissions low without compromising development goals (low-emissions development). Climate compatible development goes one step further by asking policy makers to consider 'triple win' strategies that result in low emissions, build resilience, and promote development simultaneously. Climate-compatible development is more than a technocratic issue – it is about transforming development pathways to face the climate problem head-on (Mitchell and Maxwell 2010).

Historically, economic growth has been closely linked with increased GHG emissions. Developing countries will need to break this link if they are to experience rapid growth in a carbon-constrained world; they will need to 'leapfrog' the polluting production methods used by the developed world and move straight to low-carbon growth paths. But there are massive financial, technological, and capacity challenges associated with achieving this. It is in the best interests of lower-income countries to integrate mitigation considerations into policy decisions at the earliest possible stage (Mitchell and Maxwell 2010). The scale and urgency of the climate change challenge demands an ambitious response; yet, developing countries can only take actions that are consistent with their capacity level (Willems and Baumert 2003). We do have an enormous capacity in human resources, in institutions and knowledge (to achieve climate-compatible development). What we have not done is to put them in order to be able to collect that information and also recognise that there are some gaps that need to be filled. To fill these glaring capacity gaps, higher education plays a key role in economic and social development. Africa's response to climate change is hampered by a fundamental shortage of relevant and useful information for African audiences, such as knowledge transfer of research results and good practice examples. Holloway (2014) contends that although contemporary views on higher education stress its crucial contribution to development (McGrath 2010; Obamba, Mwema, and Riechi 2013; Koehn 2013), almost inexplicably, this role was overlooked in the framing of the Millennium Development Goals. Koehn (2013) noted that higher education was 'not mentioned as an instrument of achieving even one of the eight Millennium Development Goals ... (although) attainment of every single one of them ... [would have been] much easier if a country has a strong and productive higher education system' (Harle *et al.* 2008; Lewis 2009; Damtew 2013; Mukuna and Manyasi 2015).

Higher education now has even greater role as knowledge producer and in assisting countries to become knowledge economies. Knowledge, not natural resources, is now a key factor in determining a country's global competitiveness. Africa desperately needs a strong higher education sector to assist in its rapid development. It cannot afford to lose its trained manpower to other regions. Africa needs to produce, seek, and adapt knowledge to overcome its developmental challenges. It must be part of the global knowledge economy that is locally relevant and globally competitive.

Because of limited resources, this can only be achieved by collaboration among African countries and their higher education systems, hence the need for a strong continental higher education 'space'. Research output and postgraduate training is very low due to lack of research-strong academics. Insufficient differentiation and articulation within higher education systems limits lifelong learning opportunities. African higher education is one of AU's eight priorities of the 2nd Decade of Education and is receiving increasing attention by continental and international organisations.

Revitalisation of higher education is well underway. Almost every Regional Economic Community in Africa has identified higher education as a major area of reform. There are pledges for support for African higher education from many international development/funding agencies and even from emerging economies (Brazil, China, and India). Africa can learn from the successful Bologna Process in creating its European Higher Education Area. Creating a higher education and research space fits in with AU's harmonisation strategy for African higher education. This paper is about initiatives in Eastern and Southern Africa on capacity development in higher education institutions (HEIs) in climate change. This technical capacity is what Africa needs to make headway to climate-compatible development. Countries recruit highly skilled knowledge workers globally to support their knowledge drive.

2. Statement of the Problem

Climate change will impose additional stresses on vulnerable communities, particularly those in regions that are already suffering from poverty and related issues. Many people in sub-Saharan Africa, where environmental and social conditions are marginal, will face unprecedented challenges as the region becomes hotter and drier, with increasing rainfall unpredictability. The region was identified by the United Nations Environment Program (UNEP 2008) and the Intergovernmental Panel for Climate Change (IPCC 2007) as being extremely vulnerable to the impacts of climate change. Climate change is already affecting rain-fed agriculture, pastoralism, and other activities at the core of rural livelihoods in the region, and it is undermining a host of ecosystem services that contribute to social welfare. This situation requires knowledge of the interlinked effects of climate change on livelihood systems, ecosystem services, and resilience and adaptation options. It requires new approaches to problem-solving in higher education.

Sub-Saharan Africa has diminished focus on tertiary education—a problem which is also traced to, and accumulated from the neglect in 1980s' and 1990s' of university and under-investment in education due to the ills of structural adjustment programmes. This, Obamba, Mwema, and Riechi (2013) argued, served to profoundly marginalise Africa developmentally despite explosive public demand for university education across the continent. Universities are critical actors of national innovation systems and contribute to socio-economic development. Aligning the university curriculum to the national, regional, and global goals is very important. Universities have the responsibility of doing research and sharing the knowledge with the public on how climate change affects real people, how it relates to life and changes the world we live in. Communities need knowledge, skills, and understanding for environmental management for a sustainable future. Universities, therefore, form the best platform of launching the climate-compatible development debate. The ability to

undertake and apply research is considered to bring direct benefits to developing nations both in terms of progress and prosperity and in maintaining a skilled human power.

There is a critical need to develop the capacity of graduates, researchers, government officials, and local communities to research, understand, and respond to the livelihood threats of climate change at multiple scales. Most universities in Africa lack the capacity to integrate community-based approaches to climate change adaptation into teaching, research, and community engagement programmes. They lack transformative learning approaches that draw on situated knowledge development produced through trans-disciplinary research. There is an urgent need for a paradigm shift in content and focus of community-based approaches to climate change adaptation; and that shift can be effected through new pedagogical approaches. In an African context, reference is made to the following regional policies on capacity development:

- (i) The *ACBF Report on Africa* (2011) and *Capacity Indicators* (2011), which though focusing on specific sectors such as agriculture and food security, give insights into capacity gaps in African countries;
- (ii) Africa Human Development Report (2012), *Towards a Food Secure Future*, which in Chapter 3 analyses the challenges and threats to food security and includes the issues covered in this curriculum, especially environmental challenges and perils of climate change. In Chapter 4 it indicates areas where capacity development could increase food security, reduce vulnerability, increase resilience, and promote innovation.
- (iii) *The African Development Bank Strategy for Higher Education, Science and Technology 2008*, which defines the pillars for capacity development in higher education, science, and technology; The East African Development Strategy (2011-2015/16): *Deepening and Accelerating Integration One People, One Destiny*, which in part 4 stresses the need for strengthening capacity for 'policy' and empirical research in topical areas'; the policies of AU, NEPAD, COMESA, IGAD and SADC on building capacity for resilience, especially in arid and semi-arid areas. Mentioning such policies briefly will increase the relevance and acceptability of the quest for new transformative pedagogical approaches on the continent.

However, several obstacles exist, including:

- *Inadequacy of quality of research and training*: Currently, few staff members in African universities hold PhDs or have skills to guide the research of promising young scientists (Harle *et al.* 2008, Tekeste and Abiye 2013). Ph.D. training is often supplied by universities in developed countries who end up employing their trainees (Chanie and Mihyo 2013). In regard to climate change, research capability is very weak (Wilby 2007). Research is also

needed to know what works and what does not work and what is cost-effective and likely to be sustainable.

- *Retention and recruitment of staff:* Due to poor remuneration and lack of incentives for young scholars to progress, staff mobility in universities is so high. Besides, most of the staff is ageing. Some of the early-career researchers get disappointed when they get back to their home institutions and find that there is no financial and academic support.
- *Crumbling infrastructure* Most African universities have poorly equipped research labs. They cannot, therefore, promote cutting-edge research. Access to the Internet is also unavailable (ANSTI/UNESCO 2005).
- *Lack of opportunity and support:* Most of the early-career researchers lack opportunity and support when they return back home.
- *Lack of funding:* Higher education is widely under-funded throughout Africa (Damtew 2013; TWAS 2004).
- *Paucity of quality research bids from African partners:* African researchers and their institutions cannot compete for international research funds without experience and track record. They need to carry out research competitively.
- *Lack of collaborations and networks:* Collaborations and networks in research in are at a nascent stage in Africa. Where collaborations exist, they still follow the patterns of Anglophone and Francophone divide (Adams *et al.* 2010).
- *Lack of capacity:* African countries lack the scientific and technological capacity to develop, process, and utilise the resources with which they are endowed.

To solve these problems, African academic institutions, together with Regional Economic Communities, have developed initiatives specifically addressing climate change. This chapter outlines some of the African higher education initiatives on climate change that are geared towards climate-compatible development.

3. Theoretical Framework

This study adopted the ‘systems approach’ by Jackson (2003, 3). He describes a system as “a complex whole, the functioning of which depends on its parts and the interaction between those parts.” Different types of systems can be identified: e.g. physical systems (weather system), biological systems (living organisms), and social systems (involving humans). In social systems, the parts are formed by human beings. Most social systems are characterised by openness to the environment and by being oriented towards certain goals including sustainability (Jackson

2003; UNESCO 2012a). Systems thinking is a way of looking at organisations from a holistic perspective. It puts the study of the whole before the study of the parts and refuses to accept simple solutions. Jackson (2003, xiv) illustrates: “Fundamentally, simple solutions fail because they are not holistic enough. They are not holistic because they concentrate on the parts of the organisation rather than on the whole. In doing so, they miss the crucial interactions between the parts. They fail to recognise that optimising the performance of one part may have consequences elsewhere that are damaging for the whole. This fault is known as ‘suboptimisation’.” Therefore, systems thinking claims to help in managing and understanding organisational complexity, change, and diversity (Jackson 2003, xiv).

The World Bank (2011, 29) translates the systems thinking perspective to the educational sector. To them, a system is an education system that encompasses “all learning opportunities in a given society, whether within or outside of formal education institutions. An education system consists of all parties who participate in the provision, financing, regulation, and use of learning services. In addition to national and local governments, participants include students and their families, communities, private providers, and non-state organisations. The relationships, whether contractual or non-contractual, that connect them and their resources are what make the delivery of education services possible. In such a system, decision making does not reside with only one group; instead, important decisions that affect learning outcomes are influenced by all of these stakeholders.

More specifically, the education system includes: the full range of formal and non-formal learning opportunities available to children, youths and adults in a given country whether they are provided for and/or financed by state or non-state entities (organisations together with their teaching staff, non-academic personnel and administrators); beneficiaries and stakeholders (students and trainees, their families and communities, and employers); and central and local governments and their core policy domains that keep the system running (including laws, rules, regulations, policies, resources and financing mechanisms) (World Bank 2010). Applying systems thinking implies that the functioning and performance of the total system and individual parts of the system – HEI in this case – are influenced by other parts of the system.

The systems approach is expected to contribute to the effectiveness of international cooperation in education (UNESCO 2012a). Besides teaching and learning, research is a core function of higher education, although probably not all higher education institutions (HEIs) will be engaged in actually conducting research (see the next section for explanation). A well-developed system for research and knowledge generation is of increasing importance within the emerging knowledge economy, allowing a country not only to generate new knowledge, but also to engage in scholarly and

scientific commerce with other nations (World Bank 2012). Ashcroft and Rayner (2011, 220) agree, arguing that “it is important that some universities are able to generate knowledge to provide society and the economy with relevant solutions that ensure development, address problems at the grassroots level, and contribute to poverty alleviation”. Strengthening research output and relevance first requires qualified staff. However, many developing countries have very low ratios of faculty holding doctorate degrees (SARUA 2014,10; World Bank 2012, 79). Second, to spread the results of research and appreciate the understanding and role of research, a stronger relationship between teaching and research is necessary (Altbach, Reisberg and Rumbley 2009, 139; SARUA 2012, 10; World Bank 2012, 81). Thus, different parts of the system – training, mentoring, and networking – under a favourable policy environment need to interact. The administration of the programs should be solid so as to provide skills, expertise, and mentorship to early-career researchers. The organisational infrastructure is critical in providing suitable climate for research.

4. Methodology

This was a desktop study that adopted a systematic analysis (meta-analysis of secondary data) research design. The research question that guided this content analysis was ‘*What initiatives are in place by higher education networks to realise climate-compatible development for sustainable development?*’ To answer this question, I purposively sampled five higher education consortia dealing with climate change and sustainable development. I used my document review guide to tease out background information about the collaborative network, its objectives, activities that it is engaged in, membership, achievements made so far, and challenges experienced. I singled out the Climate Impact Research Capacity and Leadership Enhancement (CIRCLE) project; the Southern African Regional University Association (SARUA) project; the Partners Enhancing Resilience for People Exposed to Risks (with a focus on Universities) – PERI-PERI U; the Moi University-OSSREA hub on Climate Change, Disaster Risk Reduction and Social Protection; and the AfriCAN Climate Portal. Reports on each of the research networks were also guided by the literature review on the role of higher education institutions in climate-compatible development.

5. Role of Higher Education in Climate-Compatible Development

Education is critical to providing fundamental skills that employers depend on to make a workforce innovative and productive. Higher education is critical to the economic success and long-term development of Africa, a continent facing several challenges of growth and development on many fronts (World Bank 2008). Higher education is the catalyst for economic

growth and poverty reduction. It is an integral part of the strategy to increase transformative investment and enhance the business environment (Nhamo 2015). Today, there is increased emphasis on creating a knowledgeable society through producing skilled tertiary education graduates. There is also a great need to establish enabling conditions to enhance the quality and relevance of teaching, learning, and research in universities. Especially action research that translates research findings into policy and community interventions is needed. The EU 2020 strategy strengthens the case for the role of education and in particular higher education for growth, jobs, and innovation. Research universities are considered among the central institutions of the 21st-century knowledge economies. This issue has been covered in three recent books: *World Class Worldwide: Transforming Research Universities in Asia and Latin America* (Altbach and Balán 2007); *The Challenge of Establishing World-Class Universities* (Salmi 2009); and *The Road to Academic Excellence: The Making of World-Class Research Universities* (Altbach and Salmi 2011).

The 1992 United Nations Conference on Environment and Development in Rio emphasises role of education in sustainable development through Chapter 36 of Agenda 21. Article 4(i) of the United Nations Framework Convention on Climate Change (UNFCCC) contains a promissory note by the parties in terms of education, training, and public awareness with regard to climate change (UNFCCC 1992). The parties agreed that they would promote and cooperate in these aspects and encourage the widest participation in the process, including that of the involvement of non-governmental organisations. In fact, Article 6 is wholly dedicated to education, training, and public awareness. The parties are reminded of their responsibilities to promote and facilitate such at the national and, as appropriate, sub-regional and regional levels. In accordance with national laws and regulations, and within their respective capacities, they should focus specifically on: the development and implementation of educational and public awareness programmes on climate change and its effects; public access to information on climate change and its effects; public participation in addressing climate change and its effects and developing adequate responses; and training scientific, technical, and managerial personnel. The parties are also tasked to cooperate in and promote, at the international level, the development and exchange of educational and public awareness material on climate change and its effects; and the development and implementation of education and training programmes, including the strengthening of national institutions and the exchange or secondment of personnel to train experts in this field, in particular for developing countries (Nhamo 2015).

At the Nagoya Declaration (Suvendrini 2014), the United Nations University in collaboration with the UN Environment Programme, UNESCO; the International Association of Universities; and the Japanese Ministry of Education all called on world leaders to support the transformative role of higher education towards sustainable development.

They affirmed that institutions of higher learning had a role to play in creating sustainable societies. It was important to tap the synergies between humanities and natural science disciplines so as to strengthen education. Higher education is expected to increase familiarity with sustainable development concepts and accentuate areas for research and development. Further, higher education institutions are forming networks and collaborations to solve the multifaceted global problems that call for cross-disciplinary, trans-boundary, and collaborative knowledge production.

The internationalisation of crises in the world also calls for academic consortia that bring together different stakeholders that include governments, the industry, the civil society, communities, and the media. The main purpose for doing this is to shift the paradigm of climate change information being generated in silos. Bringing the different stakeholders together helps to transcend established disciplinary boundaries (Max-Neef 2005). The influence of transnational knowledge consortia, combined with a growing focus on global environmental change, has amplified these trends. This has helped 'pave the way' for new cross-disciplinary curricula including Education for Sustainable Development (ESD), climate change adaptation, and disaster risk reduction (Holloway 2014).

5.1 Universities and Sustainable Development

Ten years later, at the 2002 World Summit on Sustainable Development, the role of education was strengthened and other key issues (social justice and the fight against poverty) were included as key principles of sustainable development (UNESCO 2005). Education Sustainable Development (ESD) was, then, identified as critical in sustainable development at a global level and the Decade of Education for Sustainable Development was declared. UNESCO was given the role of implementing agency for the decade. Universities are expected to be part of ESD and are challenged to utilise their main functions of teaching research and community engagement. Through teaching, universities are expected to teach students about sustainable development with a view to encouraging them to make sustainable choices (Clugston and Calder 2002). Through community engagement, universities have the potential to go beyond the university community to engage people in the community on sustainable development. The role of universities in ESD is made more important by the fact that the students they teach are the decision-makers of the future. They are the future developers and managers of society's institutions. Universities also have a great influence on industry and government policies and decisions. Investing in higher education is, therefore, essential to the production of the experts needed to address sustainability and other societal problems. African Union recognises the contributions of Higher Education Institutions (HEIs) to development in Africa. Internationally, there is increasing recognition that higher education should be re-oriented to address sustainable development

concerns. Higher education in Africa has been hitherto neglected in development efforts due to prioritisation of basic education in post-independent state formation.

Global University Network for Innovation (GUNi), the International Association of Universities (IAU), and the Association of African Universities (AAU) in May and June, 2010 did a survey on the promotion of sustainable development by higher education institutions in sub-Saharan Africa. The results of the study showed that higher education institutions in Africa are promoting sustainable development both on their campuses and in their communities. Commitment to sustainability is reflected in some of the universities' written statements. Some have integrated sustainability in their curricula, while some are involved in sustainability research and outreach projects (GUNi, IAU and AAU 2011).

African universities are also involved in sustainability partnership at various levels, and some are setting aside funds for sustainability projects. Involvement in sustainable development initiatives is, however, still significantly small in most universities. In Higher Education for Sustainable Development (HESD), AAU commits itself to ensuring that higher education remains relevant to the continent's development and prioritises sustainable development as a thematic priority on its programme. In Africa, higher education was identified to be of significance in facilitating the development process (New Partnership for Africa's Development (NEPAD) (2005), and universities are acknowledged to be key agents for improving sustainable development in the continent. The African Union has, therefore, put in place an initiative to revitalise higher education in the continent so that it can contribute more effectively to Africa's development path (NEPAD 2005).

5.2 The Role of Higher Education in Climate-Compatible Development

The contemporary global knowledge in the field of climate change and sustainable development is still inadequate because of the uncertainties around climate change issues and complexities due to different understandings of sustainable development. Therefore, there is a need to strengthen human resources and develop mechanisms that will enable such capacities to address the impacts of climate change and the associated risks on sustainable development issues that are of global concern. Essentially, there is inadequate holistic understanding of approaches to addressing climate change and sustainable-development-related issues in the developing world, especially in sub-Saharan Africa where technical expertise, financial resources, institutions, and planning are a problem. In addition, there is a need for an inter-disciplinary and multi-disciplinary climate change and sustainable development programme that will cut across sectoral, social, cultural, regional, and global issues (UNESCO 2005; SARUA 2014).

The United Nations Economic Commission for Africa (UNECA) (2012) advises that nations ought not to talk of transition to green economies without making reference to climate change, as this phenomenon is central to such debates. Education and training is highlighted by the OECD as one of the six national green economy enabling conditions (OECD 2012a, 12). UNESCO international consultation meeting on 'Transforming Technical Vocational Education and Training for Meeting the Challenges of the Green Economy' organised in Bonn October 2011 recommended that a formal guide document for greening Technical Vocational Education and Training (TVET) be developed with accompanying capacity building strategies. Additionally, in a position paper to Rio+20, the USA Partnership on the DESD maintained that education has the critical function of generating and supporting partnerships that are catalytic in nature in the context of the green economy. This is because education institutions are able to conduct research, be innovative, and share working models with industry, leading to sustained green jobs.

Nhamo (2015) asserts that higher education (including further education) has a potentially critical role to play in the transition to green economy and climate-compatible development (including climate change) readiness globally. Higher education is viewed by many as an important knowledge generation and acquisition platform where skills can also be developed for the future we want. The world's higher education institutions have been involved in initiatives that include conservation education, environmental education, education for sustainable development, and climate change education.

Nhamo (2015) cites Bildungskolalition (2011), a team that shares the same views and suggests that further education training and green jobs qualifications are necessary for galvanising green jobs and addressing youth unemployment. It is said by these groups that higher education must provide scientific qualifications for academic-related job opportunities in the green economy. Sub-Saharan Africa is experiencing positive economic development, and there is increasing understanding of the important contributions universities have to make if African societies are to achieve the next stages of development. However, as Africa has become ever more affected by increases in poverty, and state spending has come under pressure, universities have been neglected, and have suffered enormously from brain-drain.

6. Climate Change Initiatives by Regional Economic Communities

Eastern and Southern African regional economic communities (RECs) underscore the importance of higher education in their economic development agenda. They also value research by higher education institutions because research guides policy decisions. These regional economic communities (RECs) recognise that, as they promote economic

development, they cannot ignore climate change mitigation and adaptation so that their development is climate-compatible.

In this section I briefly present three RECs and what they are doing with regard to climate change. These are:

6.1 The East African Community

The East African Community (EAC) is a regional economic and geographical body that is composed of six countries, namely: Kenya, Uganda, Tanzania, Rwanda, Burundi, and South Sudan. The EAC is committed to responding to the effects of climate change through adaptation, mitigation, research, and addressing technical and financial constraints as well as policies, strategies, and organisations working on climate change. Through the East African treaty, member states of the East African Community have developed a regional climate change policy. This has been followed by the establishment of the East African Community Climate Change Fund to operationalise and implement the strategy. Efforts have also been made to manage trans-boundary ecosystems in the region through specialised institutions like the Lake Victoria Basin Commission and the Lake Victoria Fisheries Organisation. A Trans-boundary Ecosystem Management Bill was passed by the East African Legislative Assembly in 2010 (Viljoen 2013).

6.2. Common Markets of Eastern and Southern Africa

The Common Markets of Eastern and Southern Africa (COMESA) has also put in place comprehensive climate change initiatives. The goal is to achieve economic prosperity amidst the challenges of climate change. The initiative aims at addressing the impact of climate change in such a way that it would ensure economic and social resilience for all generations. COMESA has developed a model for coordinating climate change initiatives among various stakeholders. These include sub-regional organisations, governments, the private sector, community-based organisations, entrepreneurs, women's organisations, farmers, and research organisations (Viljoen 2013).

6.3. Southern African Development Community

The Southern African Development Community (SADC) has committed its members to sustainable development and protection of the environment amidst developmental and climatic challenges. The member states have been encouraged to ratify various multilateral environmental agreements including UNFCCC, the United Nations Convention to Combat Desertification (UNCCD), and the United Nations Convention on Biological Diversity (UNCBD). Further, SADC has two main interventions to address the impact of climate change: the Climate Change Adaptation Strategy in the Water sector and the SADC REDD+ programme.

7. Climate Change Initiatives by Regional Higher Education Research Networks in Africa

7.1. Climate Impact Research Capacity and Leadership Enhancement

7.1.1. Rationale

The CIRCLE project is funded by the U.K. Department for International Development (DFID) in collaboration with the Association of Commonwealth Universities, UKAid, and Vitae. This project sits at the African Academy of Sciences. The main objective of this project is to create a critical mass of multi-disciplinary early-career researchers and mentors in climate change in sub-Saharan Africa so as to ensure sustainability. This is a response to the climate change threat whose impact will hit Africa the worst (IPCC 2007). Large populations of Africa are said to be vulnerable to climate change (UNEP 2008). Through research, what works and what doesn't will be documented and will provide lessons for future generations. Research will also provide home-grown solutions to the challenges that climate change poses. African Academy of Sciences agrees with Wilby (2007), who posits that African research capability in the area of climate science and climate change impacts is very weak. This is evidenced from the low number of publications by African scholars in climate change. African early-career researchers lack funding for research, infrastructure, mentors, and supervisors in climate change, challenged with poor research governance of their institutions and governments, among others. Another driving force behind this initiative is the fact that most of the existing capacity building interventions are focused on delivering M.Sc. and Ph.D. graduates, who, upon their return to home institutions, often fail to access research funding opportunities needed for building sustainable research careers. Most of them end up moving out of the field.

7.1.2 Project Objectives

This project aims at leveraging all the above by:

- providing a combination of financial and technical support to selected African early-career researchers and their research institutions by drawing on the expertise of an internationally recognised centre of excellence in climate change;
- enhancing climate change knowledge through research Fellowships while also providing critical support for institutions to capitalise on the skills and knowledge gained by their returning fellows in climate change. The research skills in African scientists will be acquired through experiential learning whereby the research fellows do actual research and publish in peer-reviewed journals under the guidance of their supervisors and mentors. The research governance skills of participating African research institutions are strengthened;

- building the capacity of research directors of home and host institutions on strengthening institutions to support early-career researchers in climate change;
- promoting climate change knowledge publication and dissemination for research fellows on their research outputs. These publications should be of high quality, peer-reviewed, and internationally recognised;
- building the capacity of supervisors and mentors of the climate change research fellows;
- strengthening support for research institutions to support early-career researchers in climate change;
- ensuring a gender-balanced increase in the number of high quality African researchers on climate change by successfully designing, delivering, and communicating peer-reviewed research in SSA;
- facilitating and supporting an active network of researchers between African countries and partners in Europe;
- assessing research support for early-career academics in Africa; and
- sustaining support for early-career researchers in climate change.

7.1.3 Essential Components of Building Research Capacity

The CIRCLE project identified four essential components of building research capacity. These are:

- availability of tangible assets, which includes physical facilities, infrastructure, equipment, and technology;
- human capacity - Here the focus is on the processes of training, education, and professional development of fellows, supervisors, and institutions so as to acquire knowledge and skills, abilities, values, and social assets for improved productivity;
- Organisational skills - This focuses on the coherent mission and mandate of the organisation, its corporate governance and management of research, operational procedures, funding of research, and provision of other resources necessary for research; and
- enabling institutions - This refers to the political and economic context in which the research is being carried out, institutional relationships, and national and regional research policies.

Although all the four components lead to high quality research in climate change, this project is emphasising on the quality of human capital. It is strengthening their knowledge, skills, and competencies to design and deliver high quality research. The project is hosting 40 M.Sc. and 60 Ph.D. fellows, 200 mentors working with effective African research institutions. The African Academy of Sciences with its development partners hopes to

produce internationally recognised researchers who will publish cutting-edge research in leading, peer-reviewed journals on climate change. As said earlier, by building the capacity of academic researchers in African universities, climate-compatible development will become a reality, and development programmes will be sustainability because of this critical mass of scholars. These scholars will advise their governments on mainstreaming climate change into their development policies, strategies, and programmes. Since climate change is a human-behaviour-induced problem, these researchers will endeavour to link research outputs with communities in community outreach programmes.

7.1.4 Activities Carried out So Far

In February 2015, the CIRCLE champions' workshop was held in Nairobi. Its theme was to strengthen the institutions on supporting the early-career researchers (ECRs). The research institutions and their leaders need to understand their roles for them to support the ECRs effectively. It emerged that, throughout sub-Saharan Africa, the ECRs feel let down by their supervisors or vice versa. Worse still, the supervisors may be willing to give very high quality mentoring and supervision but institutional bureaucracy or challenges hinder them. Further, the ECRs find it difficult to go away from their home institutions to embark on the research journey because most of them are not released. This puts them in a dilemma. Some come from host institutions very anxious and enthusiastic to further their research career only to find that their home institutions lack the necessary infrastructure that they need. It also emerged that most institutions concentrate on teaching, and not on research. Apparently, research is not a leading priority in most universities in sub-Saharan Africa. Research governance is an issue that needs to be looked into. The CVFs also reported that academic jealousy is rampant in universities with established researchers blocking the way of ECRs.

In May 2015, the CIRCLE Mentoring Train-the-Trainer Workshop was held in Johannesburg, South Africa. Here, we had three mentoring case study presentations, highlighting personal experiences and institutional climate for mentoring, roles and activities of an effective mentor, approaches to mentoring, mentoring using the Vitae Researcher Development Framework, and setting up and administering an institutional mentoring programme. Pertinent issues were raised and the mentors/supervisors were sent home with various questions to ponder over. They also raised various questions. The discussions were very fruitful and enriching. It emerged that, in most cases, supervisors are not mentors. It also emerged that the strategic plans of most sub-Saharan universities do not factor in the needs of mentors and mentees. The following questions were discussed but they still beg for answers:

- i. How can support for early-career researcher be aligned with institutional and national priorities?

- ii. How should early-career researcher support be linked to career progression?
- iii. What opportunities and challenges might there be for maximising resources in early-career researcher support?
- iv. What are the biggest priorities for early-career researcher support?
- v. How can externally-funded programmes focusing on early-career researcher support be more sustainable?

The framework of this collaboration is such that there are different partners using the systems theory, i.e., playing different roles and harnessing each others' synergies. There is systematic exchange of information and best practices, joint programming, implementation of joint activities, and trans-national research activities. There is also north-to-north, north-to-south, and south-to-south learning. The sustainability of this project is ensured through continuous learning using webinars and blogs. All participants have also formed a learning community where they continuously share knowledge. The academic leaders are also directly involved in the project to ensure that they support early-career researchers of the universities involved. They form an important part of a varied portfolio of collaboration.

7.2. Southern African Regional University Association

7.2.1 Rationale

Southern African Regional University Association (SARUA) drew together a number of leading experts within their fields from across the SADC region to present and discuss their views with Vice-Chancellors at a two-day dialogue event titled 'Climate Change Adaptation and Higher Education: Securing Our Future' held from 21 - 22 October 2010 in Mauritius. Within higher education institutions, the urgent need for mainstreaming climate change into undergraduate and postgraduate curricula across faculties and departments was emphasised, firstly, to create awareness of knowledge (and research) gaps, and, then, to develop research interest and capacity in filling the gaps. The answer to the questions above lies in the epistemological challenges and, indeed, opportunities go beyond climate change as a particular 'subject' or focus area. These can be applied to any number of complicated theoretical and 'real world' issues, requiring multidisciplinary approaches and involving a high degree of uncertainty, complexity, and risk (Piyushi 2010). The SARUA initiative arose as a result of a meeting in 2010 of vice-chancellors at a SARUA leadership dialogue event in Mauritius to consider how universities in the region might respond to the challenge of climate change and adaption.

Their aim was to answer the following questions: What does this mean for the public universities in the countries of sub-Saharan Africa, committed to responding to the development challenges of the region? How can the universities contribute to a better understanding of the phenomenon itself through their core missions of teaching, research, and community engagement, and, more importantly, build the capacities that will enable the

region and its people to prepare for and to cope with some of its effects? What changes will be required to the pedagogical approaches and epistemological models currently employed by our universities, and how can the universities of the region collaborate to ensure that scarce resources and expertise on these matters are leveraged to the best effect? The lack of national institutional capacity for climate change, including a lack of support for climate change research and development, are arguably the most significant needs.

Cognisant of the fact that many regional universities are doing good work on aspects of climate change, a 'non-soloed' approach was required as universities are divided into disciplines and a trans-disciplinary approach is needed. SARUA commissioned an extensive study aimed at establishing needs and existing institutional contributions to climate-compatible development knowledge production, incorporating research, teaching, and community engagement in Southern Africa, involving primarily the universities that are part of SARUA. This mapping study examined the role of higher education in contributing to climate-resilient development pathways. This study brought together information from twelve southern African countries across a wide range of disciplines on climate-compatible development. A wide range of university professionals from various faculties such as science, agriculture, law, education, humanities, architecture, engineering, and health, amongst others, were put on board to establish where and how climate-compatible development research, teaching, and outreach is already taking place, and where the gaps may be. Additionally, the perspectives of multiple stakeholders on knowledge needs and gaps in this area were captured: from national stakeholders concerned with climate change and climate-compatible development, to university professionals, to members of the civil society and the private sector.

7.2.2 Objectives of the Project

The objective of this study was to build the capacity of the region's universities to respond comprehensively and innovatively to the region's climate change challenges via research, teaching, community engagement and policy outreach contributions that will strengthen the region's capacity for climate -resilient development in the future. Four regional networks which include seven potential research-themed clusters (research network); a curriculum innovation network; a capacity building network, and a policy engagement network were analysed. The study was based on questionnaire data, document analysis, and consultations with universities and stakeholders involved in climate-compatible development knowledge production in the region. It provided the first 'baseline' analysis of the role of universities in knowledge co-production for climate-compatible development. It is accompanied by a substantial database and a set of 12 country reports. Primary funding was received from the Climate and Development Knowledge Network, CDKN,

and additional contributions were provided by a number of others, including the SADC Regional Environmental Education Programme. A five-year SARUA programme on climate change and development has emerged from this mapping study.

7.2.3 Collaborations and Networks within Higher Education

Previous SARUA research has shown the necessity of regional collaboration and especially the need for more South-South collaboration in research. The mapping study has reinforced this: while there is research being done in SADC countries, little of this is being published in the international arena by Southern African researchers. There is also a shortage of doctoral graduates and supervisors in the region. “If Southern African countries wish to respond innovatively to climate change impacts, they need to prioritise new knowledge production. The overall vision of the SARUA programme is to create a system of knowledge co-production that provides Southern African researchers with opportunities for capacity building and relevant, high quality knowledge production. Individual institutions need to be well-managed in order to attract, develop, and retain quality academic staff. For this reason, the project also focuses on the establishment of institutional and capacity development. The programme aims to significantly enhance the climate-adaptive capacity and resilience of the SADC region through the development of a collaborative network of higher education institutions capable of pooling resources, maximising the value of its intellectual capital, and attracting significant investment into the region. This will involve step changes in:

- research, teaching, and knowledge generation on climate change, adaptation measures, low-carbon development options, and the associated costs and benefits;
- the dissemination of information and knowledge amongst all stakeholders;
- sensitising communities, governments, and the private sector about the risks of climate variability for development prospects in the region;
- regional evidence-based policy development and implementation; and regional capacity for active participation in international policy networks.

7.2.4 The Study Proper

The mapping study was multidisciplinary, involving active climate change researchers from a range of disciplines including, but not limited to, the Natural and Environmental Sciences, Agriculture, Engineering, Law, Education, Psychology, Sociology, Gender Studies, Development Studies, Economics and others. It was also multi-voiced – involving policy makers, national and regional stakeholders such as government department officials and UNFCCC. The mapping study involved 12 of the 15 countries in the SADC region and 57 of the 62 universities that are affiliated to SARUA as at the end of 2013. In some countries, universities not yet

fully affiliated with SARUA, also participated in the study. In each of the 12 countries, country coordinators, organised business national research organisations, major national non-governmental organisations and community representatives, and university managers, staff, and students participated in this mapping study. The study is the result of extensive regional collaboration, including a regional team of 18 specialists and with 15 universities making direct contributions. All countries tended to identify a range of knowledge gaps within the agriculture, food security, natural resources management, health, and energy priority areas. In some cases, research capacity on climate change, speaking broadly, simply does not exist, while in others it is a question of an insufficient level of up-to-date knowledge in certain specialised areas. There is a mismatch between the skills of graduates and market demands – this is a general shortcoming, not restricted to responding to climate change. One example, across a range of scientific disciplines, was that graduates are not being provided with practical skills. This relates to the availability of funding for higher education, and is a broad and complex issue.

A common theme from all countries was that existing mechanisms and capacity are insufficient to deal with complex and diverse climate issues, which will require a strategic, coordinated, and harmonised approach. Within the context of urgency for action on climate change, Southern African countries will need to step up existing efforts to make development more resilient according to national needs and priorities. In the context of the undergoing international climate negotiations, all countries will need to develop ‘national offers’ or contributions for emissions-reduction proposals, as well as set out actions for adaptation. These will provide a way to link the 2015 international climate agreement more closely to domestic debates and national circumstances. All of this will entail significant regional preparation, underpinned by action-oriented research. As the mapping study has found, developing capacity for the research to assist in unlocking all this will require strengthening individual disciplines, as well as building research capabilities and removing barriers, including through institutional reform. It will also require concerted efforts to enhance the climate-change-related competences, knowledge, and expertise of those who will develop and deliver many of the capacity development initiatives – the researchers, educators, trainers, and their partners. The authors of the document concede that, while climate-related capacity and research development needs are many, there are existing nodes and centres of expertise that can play a strong role in further developing research and teaching capacities to address the identified priorities and gaps. What is required is a strategic approach that builds upon existing expertise, addresses the most pressing shared priorities while allowing for local specificities, and assists the countries and the region to do so in a way that also positions them better for the potential opportunities inherent in the unfolding international architecture of climate agreements and funding institutions. To this end, a set of proposed priority research themes, to be

addressed through regional research clusters, has been developed, which also links to wider research agenda that are being put forward under, for example, the Future Earth Global Sustainability Research Plan.

7.2.5 The Knowledge Co-Production Framework of SARUA

Overall, the vision of the SARUA programme is to create a system of knowledge co-production that provides southern African researchers opportunities for capacity building and relevant, high quality knowledge production. This mapping study, therefore, provides a Knowledge Co-Production Framework for climate-compatible development in southern Africa for trans-disciplinary collaboration and knowledge co-production across research, teaching and learning, and community engagement, and highlights the gaps to be addressed by policy makers across the region to enable universities to have a material impact on the region's future development path (Piyushi 2014). The key findings of the needs analysis are as follows:

- i. Despite different contexts, there is a commonality between countries on broad findings. The status of climate-compatible development (CCD) knowledge and research and both individual and institutional capacities will need to be enhanced significantly in all countries, in both specific and cross-cutting ways, to address the considerable observed and projected climate impacts.
- ii. Diverse regional understandings of CCD are strongly linked with adaptation and mitigation and sustainable development. Most national policy documents do prioritise both adaptation and mitigation actions, with some of them framing it as resilient and low-carbon development. However, a general framing is that adaptation should be the main priority in the country's development goals, while, at the same time, embracing any developmental opportunities of cleaner energy and other low-carbon technologies.
- iii. There are a range of broad priority areas for addressing climate change. These include energy, infrastructure and industry, education, capacity development, policy and institutional strengthening, integrating adaptation and disaster risk reduction, governance, participation, and empowerment.
- iv. Institutional capacity and support for CCD research and development are significant needs.
- v. Knowledge needs are diverse and yet also systemic. The scope of the specific knowledge needs identified across the 12 countries reflects a range of disciplines, spanning the physical, natural, social, agricultural, educational, engineering, health and economic sciences. Therefore, in the HEIs, it emphasises the urgent need for mainstreaming climate change into under- and postgraduate curricula across faculties and departments, firstly, to create the awareness of the knowledge (and

research) gaps, and, then, to develop research interest and capacity in filling these knowledge gaps.

- vi. All countries tended to identify a range of knowledge gaps within the agriculture, food security, natural resources management, health and energy priority areas; many of the knowledge gaps are related to the lack of systematic and reliable long-term data in different sectors to serve as baselines for research, modelling and monitoring. Stakeholders from different sectors in many countries identified the need for systemic, integrated perspectives on global change and climate-compatible development concerns at multiple scales and levels.
- vii. Gaps necessitate transcending disciplinary boundaries.
- viii. Research capacity gaps are largely correlated with knowledge needs. A regional commonality was the significant need for fundamental research on vulnerability and impact assessment across a range of sectors and at different levels, highlighting inadequacies in these understandings that would need to be addressed in order to develop adaptation strategies and enabling environments for these to be implemented. Social research needs such as cultural change, gender and climate change, and community participation in climate change and CCD, which were not always as well articulated in national climate change policy and strategy were emphasised.
- ix. Contextualisation and localisation of climate change research is important.
- x. It is important to understand and value indigenous knowledge systems for resilience. This would also be important for developing integrated adaptation-mitigation approaches, although this was not often specified, given that a number of uses of indigenous knowledge, for example in community forest management or conservation agriculture approaches, have the potential to advance practical integrated adaptation-mitigation approaches.
- xi. Individual capacity gaps require a system-wide response.
- xii. There is a mismatch between skills supply and demand, and a need for integrative skills.
- xiii. Research and capacity development to engender social change is important.
- xiv. Significant institutional capacity gaps require a concerted response. Many constraints are related to a widespread lack of coordination and holistic approach. Knowledge management emerges as a significant institutional capacity gap. Most countries cited the limited knowledge and research on what types of CCD responses exist in the country, calling for the need for a database/informational management system that would collate *inter alia* research on different aspects of climate

change and CCD, and climate change implementation projects and programmes. A more coherent and supportive research framework, with enhanced funding to enable all forms of research on climate change, is also needed.

- xv. There is a cyclical relationship between individual and institutional capacity gaps. An integrated approach to knowledge, research, individual and institutional capacity development is needed, where improved resourcing, and more active and attentive government and legislative support is needed.
- xvi. The wide-ranging nature of the knowledge, research, and capacity needs, together with the high level of commonality across countries, calls for a strategic and integrated approach to capacity development. While there is a need to integrate climate change and CCD into a variety of disciplines to produce the specific knowledge necessary, CCD capacity must also be developed cross-sectorally, and should involve multiple stakeholders at all levels of society. Competencies include new financial management skills, new policy formation and networking skills, leadership and ethical competencies, as well as knowledge dissemination competences. This need for strategic and integrated approaches reveals the need for multi-, inter- and trans-disciplinary approaches to research and knowledge co-production, as integrated approaches cannot be developed via silo-based approaches to research only. Very little mention is made in policy documents of capacity building for those who are to offer all of these intended education, training and capacity building programmes to address the individual and group-based capacity needs, although this point was raised in the workshops.

7.2.6 Challenges Facing SADC Countries in CCD

7.2.6.1 Research Methodology and Training: The SADC Regional Environmental Education Programme (SADC REEP) regional capacity assessment emphasised the need to give attention to the capacity building of research, environmental education and training professionals at all levels (in universities and higher education institutions, in TVET colleges, in NGOs and CBOs, and in government extension units) if southern African countries are to address their research and capacity development needs, as articulated in the needs analysis undertaken for this mapping study. Little is said in any of the policy or strategy documents, or even in national research plans where these exist, about research methodology and research training; yet, this is core to the development of new approaches to CCD research and knowledge co-production.

Research policy and national infrastructure is needed for CCD research. Research co-ordination, data sharing, and knowledge management were identified as key concerns, for CCD research centres of excellence,

centres of expertise, and nodes of expertise for CCD exist in almost all SADC countries. Some of these are still in their infancy and require capacity building. Few countries have well-developed research systems and incentives that provide an enabling environment for university-based CCD research. Research funding was repeatedly noted as a critical limiting factor. A national research policy that incentivises researchers to publish in international journals can have a significant impact on research output. CCD research capacity building and strengthened platforms for research innovation are needed, for CCD research involves the introduction of new approaches to research within virtually all existing disciplines. Added to this is the challenge of introducing inter- and trans-disciplinary approaches to research.

There were few examples of inter- and trans-disciplinary research on the ground. CCD research requires ICT-enhanced research systems. One of the fundamental areas of climate change and CCD-related research is observation, monitoring, and modelling. Such research requires sophisticated ICT-enhanced research systems, to which only a few countries have access at the university level. However, international programmes have tended to support provision of equipment to national meteorological systems; this indicates the requirement for new partnerships between universities and these institutions. Knowledge sharing and participation platforms for CCD need strengthening. Few platforms for sharing experience of CCD-related research exist, especially for more innovative approaches to research such as situated, multidisciplinary, and trans-disciplinary studies. Current patterns related to universities as producers and co-producers of CCD knowledge show this to be a relatively new and emergent area of research.

In general, CCD research is a 'new area' of research for many of the SADC researchers involved, with most researchers working in this area being involved in it for approximately five years, despite having much longer academic careers. There are some experienced CCD researchers with ten years of experience or longer in this field, but they are not the majority. This reflects a process in which academics are 'self-specialising' into climate change and CCD research, and has implications for ongoing capacity building. Discipline-based research still dominates, and there is lack of interdisciplinary cooperation. The mapping study showed an enduring strong dominance of single-discipline research, with multi-, inter-, and trans-disciplinary research approaches still in their infancy, and, in some places, not developed at all. This contrasts with international scientific trends responding to complex issues such as climate change. While there is some progress, there are still challenges associated with multi-, inter, and trans-disciplinary approaches to CCD research. Amongst those who were already engaged in multi-, inter-, and trans-disciplinary research and who had seen the benefits of such research approaches in relation to the CCD problems being studied, some still requested capacity building for these approaches. There was, in

particular, a strong call for university leadership to support these new approaches to research, as they also require structural change in universities at the highest level.

7.2.6.2. Barriers to Collaborative Research in Climate-Compatible Development: The SARUA mapping study found out that universities have an important role to play in CCD knowledge production and co-production. They found out barriers to collaborative research that need have to be addressed.

7.2.6.2.1 Internationalisation of CCD Research, International Peer-Reviewed Research

i. *Publishing, and Engagement with Research Networks:* Linked to the above point is the need to strengthen internationalisation of CCD research and research networks. One of the most striking findings of the mapping study was that, although there is research on climate change and CCD taking place in SADC countries, this is often not being published by SADC researchers; it is published by international researchers. The study identified a range of international and regional research networks such as the START (global change System for Analysis, Research and Training) programme, the Regional Agricultural and Environmental Initiatives Network – Africa (RAEIN-Africa), the Benguela Current Commission, the Southern African Science Service Centre on Climate Change and Adaptive Land Use (SASSCAL), Africa Monitoring of the Environment for Sustainable Development (AMESD), Africa Environmental Observation Network (AEON), WATERNET and the Famine Early Warning System (FEWSNET), to name a few. These institutions were playing an important role in both CCD research capacity building and research networking. Research funding systems for CCD are needed. Research publishing is a critical area to strengthen, to ensure wider credibility and uptake of southern African CCD research and to inform policy.

It was also noted in the mapping study that in many cases SADC researchers find it difficult to access international research funding, as this often requires a complex set of partnerships, which are also increasingly multidisciplinary and multi-institutional in nature. Partnerships with international research networks and organisations need to be encouraged.

7.2.6.2.2 Financial Management of Research Funds: Few of the SADC countries had dedicated national research and development funds that were ‘set aside’ for climate change and CCD research, except for South Africa, which has a funded 10-Year Innovation Plan that includes a National Grand Challenge on Global Change (including climate change) and another National Grand Challenge on Energy, both being relatively well-funded by the Department of Science and Technology. Most national governments do have Science and Technology Innovation strategies, but

these are not (as yet) strongly oriented towards CCD research, leaving a big funding gap for the kind and scope of research that is required. Staff capacity building, especially at PhD level, is needed.

7.2.6.2.3 Curriculum Innovation: With regard to curriculum innovation, the study showed that those that did have PhDs were having a strong influence on curriculum innovation, were more strongly networked and linked into international partnerships, and were also making substantial contributions to policy processes. Curriculum development and innovation for CCD requires a strong support. There were very few examples identified of interdisciplinary curriculum development and teaching; a few dedicated courses/modules focussing on CCD-related concerns are only found at undergraduate levels. Curriculum innovation at a Master's degree level was beginning to take place in various forms: new Master's degrees as well as focussed integration of CC/CCD into existing Master's degrees, CCD and PhD programmes, and supervision were also raised in relation to curriculum innovation, although PhDs are generally not 'taught' programmes in SADC.

7.2.6.2.4 Specific Capacity Building Programmes for Supervisors and Ph.D. Candidates: Capacity building programmes for Ph.D. holders and Ph.D. supervisors were needed to strengthen Ph.D. offerings; especially within a cross-institutional partnership framework, 'key competencies' for CCD learning were identified, which included more generic competencies, such as systems thinking competence, anticipatory competence, strategic planning competence (including use of modelling tools, etc.), normative competence, and socially engaged practical competence, in addition to CCD area specific competencies, e.g. town and regional planning competence or agricultural adaptation competences. There is a strong demand for curriculum innovation support, which includes curriculum development support to develop new programmes and/or strengthen existing programs. Student engagement with CCD issues is relatively low.

8. Partners Enhancing Resilience for People Exposed to Risks (with a Focus on Universities)

8.1. Background

Priority 3 of the Hyogo Framework for Action explicitly underlined the value of 'knowledge, innovation, and education to build a culture of safety and resilience'; its primary emphasis was on the integration of disaster risk reduction into school curricula, and on educating younger generations (UNISDR 2013; Mukuna 2013). There is a shift beyond an earlier focus on hazards and disaster mitigation to increasingly address issues of risk and resilience. The introduction of peer-reviewed journals in the field not only widens the avenues for communicating disaster risk

knowledge domain, but it also advances education and research in the field, signalling the scholarly legitimacy of the disaster risk discourse in the higher education enterprise. Despite previously limited international support advancing disaster-risk-related tertiary education in Africa, innovative programmes have emerged in recent years. A multi-country disaster-risk-related HEI collaboration known as PERI-PERI U also unfolded in Africa during the past decade. This is a relatively recent innovation in a bid to advance scholarly partnerships in disaster-risk reduction. The emergence of the PERI-PERI U academic partnership in Africa, while not global, also speaks to the challenges faced and innovations adopted in introducing sustainable 'novel', cross-disciplinary, applied Disaster-Risk Reduction (DRR) higher education programmes under severe resource constraints (Holloway 2014).

PERI-PERI U constitutes a purposive HEI partnership to promote strategic human and institutional capital in the disaster risk domain by explicitly integrating disaster-risk-related concepts and practices into higher education curricula (www.riskreductionafrica.org). Beginning in 2006, it now represents a self-organising consortium of ten African universities that have worked collaboratively to 'jump-start' formal higher education programmes in the broader disaster-risk reduction domain, transgressing disciplines, languages, and national/regional divisions. The partnership has also sought to systematically advance a culture of prevention in the participating countries through the institutional integration of academically robust, yet socially responsive, undergraduate and postgraduate disaster-risk-related academic programmes. The rationale underpinning the consortium recognised the crucial role played by higher education institutions in advancing strategic human capital to address complex risks. Acknowledging the emerging expansion of academic expertise in Africa, PERI-PERI U was conceptualised to leverage and collaboratively develop this continental capacity by strengthening risk knowledge and strategic human capital to support national and local disaster-risk reduction efforts.

The partnership now involves more than 70 academic staff and offers 20 disaster-risk-related academic modules and programmes across a range of applied disciplines and practice fields. It has also generated hundreds of graduates, many of whom have taken up employment in government as well as non-governmental and other organisations. These activities have been complemented by numerous local short courses for practitioners, applied 'service learning' in at-risk communities as part of formal coursework, as well as the provision of local expertise for commissioned research and DRR policy development.

The partners acknowledged that strengthened educational capacity to reduce local risks was an underpinning requirement of social and economic development, and that there was urgency to build strategic and technically competent human capital in the field. The consortium

also committed itself to bridging the divide between Africa's institutions of higher learning and the practice fields of disaster-risk reduction and humanitarian action. These imperatives have been the driving force behind the consortium's achievements in making socially responsive disaster-risk education accessible, training, research, and community outreach. There was a shared appreciation that poorly understood and managed risk accumulation processes were disrupting and undermining development potential in Africa. This not only applied to more widely-known famines and protracted armed conflicts that have led to large internal as well as refugee displacements, but it was also relevant to the smaller, highly frequent, 'hidden' events that seldom attract international attention, which actually exact significant hardships and set-backs to local development (Holloway 2014).

8.2. Linking Disaster-Risk Reduction to Higher Education

HEIs have become more purposefully engaged in the field of disaster-risk reduction (van der Waldt 2013). He posits that there is number, variety, and geographic spread of academic programmes now offering disaster-risk-related qualifications. Similarly, it is reflected in a surge of new academic journals that step beyond previous preoccupations with natural hazards and emergency management into the domains of risk and resilience. Also, there are new transnational platforms for collaboration and knowledge consortia that include academic as well as other stakeholders. There is a rising trend towards post-graduate disaster-risk-related education in countries exposed to recurrent natural and other threats. Several mid-level developing countries have invested heavily in building strategic human capital level in disaster-risk management (Brinkerhoff and Morgan 2010).

Higher education and applied research, while not explicitly excluded from the Hyogo Framework for Action knowledge, innovation, and education theme, were more narrowly framed as a source of practical endeavours in building disaster-reduction capacities. In addition to their core responsibilities of teaching, learning, and research, higher education institutions also maintain risk-related data bases, as well as analyse disaster risks and support disaster-risk-related policy and planning. More recently, their active engagement was materially reflected in the insights and expertise of around 50 contributors associated with institutions of higher learning in the 2013 Global Assessment of Risk (www.preventionweb.net/). Similarly, Holloway (2014) notes that more than 200 contributors and expert reviewers drawn from 156 higher education institutions were acknowledged in the Special Report on Extreme Events of the Intergovernmental Panel on Climate Change (IPCC 2012, 545–553).

The higher education enterprise has long played a crucial role in the disaster-risk domain. This includes the management of specialist data bases (e.g. EM-DAT: The OFDA/CRED International Disaster Database,

located at the Universite de Louvain, Brussels, Belgium). Historically, however, disaster-risk-related education programmes have been difficult to implement within institutions of higher learning because of their complex, cross-disciplinary, and applied character. Moreover, like sustainability science (Yarime *et al.* 2012), the domain of disaster risk reaching across a complex interdisciplinary and applied terrain has hindered its recognition as a legitimate field of scholarship. They further argue that the introduction of new academic programmes in sustainability science (and related fields) should incorporate elements of being inter-disciplinary and trans-disciplinary. New academic programmes also require a coordinated adjustment of institutional arrangements across a diverse array of academic programs, scientific journals, associations and societies, networks and alliances, workshops, and conferences (Yarime *et al.* 2012; Yarime 2011).

8.3 Activities of the Project

Risk management is an important development priority in Africa that requires strong interdisciplinary thinking and applied problem-solving skills, given the continent's various and complex risk conditions, along with its accelerating urban growth trajectory, demographic profile, and climate change projections. PERI-PERI U consortium members created innovative, cross-disciplinary, and applied disaster-risk curricula that were grounded on solid disciplinary foundations. Partners also aligned curricula with their local risk conditions, identifying their teaching and learning programmes with socially responsive imperatives. There is now a growing portfolio of relevant cross-disciplinary disaster-risk academic programmes across the continent offered in diverse languages (e.g. Afrikaans, Amharic, Arabic, English, French, Kiswahili, Malagasy, Portuguese). Their various disciplines include agriculture, engineering, economics, environmental science, public health, and urban planning.

Because disaster-risk management is a multi-disciplinary field with issues as diverse as food security and urban risk, it involves many stakeholder groups. These include specialised professionals such as architects and public health workers, as well as emergency responders and community development workers. PERI-PERI U has attempted not to overlook these groups in its capacity-building work, recognising that practitioners are at the forefront of local risk management.

Between 2008 and 2013, PERI-PERI U partners numbered 2,200 professionals and practitioners through more than 80 short courses across the continent. This is a wide audience, including community health practitioners, local government officials, as well as health and social programme animators. Increasingly, local and national authorities are drawing on HEI expertise for the customised training of government officials. The provision of accessible short courses for government and other stakeholders has already generated tangible benefits for applied disaster-risk research. This has taken several forms, including postgraduate

studies, commissioned research, and dedicated faculty projects. These efforts have produced a wealth of information about previously under-researched and poorly understood risks within Africa. Since 2006, the focus on engaged scholarship in diverse risk contexts and the multiple disciplinary lenses of PERI-PERI U have resulted in numerous collaborations at local, national, regional, and continental scales. They underline a commitment to multi-stakeholder engagement, often in difficult and complex risk settings.

The consortium is privileged to represent the continent's higher education interests as a member of the African Working Group on Disaster-Risk Reduction, and at both regional and continental levels. It collaborates closely with governmental, intergovernmental, and United Nation's representatives. Its involvement with nongovernmental organisations and civil society organisations allows 'field access and experiences in grassroots project implementation' (Shaw *et al.* 2009). This is viewed as a key element of effective disaster-risk-related education and research undertaken by members of the network. The consortium/network model is also a valuable platform for support, especially for overcoming internal institutional obstacles that face an emerging, interdisciplinary field. The adoption of collegial governance model provides scope for individual partners to develop contextually relevant education, research, and outreach activities for local risks and to exchange this knowledge seamlessly.

9. The AfriCAN Climate Portal

Intensive media coverage and campaigns for increasing public awareness and uptake of climate change research results have been largely absent in Africa, particularly outside major urban centres. Frequently, African voices are absent from the international climate debates; yet, Africa's response to climate change will be led by the communication of research results to stakeholders who will translate research results into activities on the ground. Martha (2014) has documented the first and main successful work done to build a scientific and technical consortium. The AfriCAN Climate Portal is an innovative web-based knowledge platform for the sharing of climate change research and good practices. It brought together an active network of European and African researchers and communication experts. In addition to disseminating information on climate change research and policy, the project facilitated the widespread sharing of indigenous knowledge and examples of good practice. The anticipated effect has been an increased uptake of research results and their translation into practical projects that have a direct impact on people's lives. Africa's response to climate change has so far been hampered by a fundamental lack of knowledge transfer. Since the 1980s, very many policies have been formulated with regard to climate change. This has been of great value in

formulating realistic policy objectives. Now it is time to translate these results into action. There is a clear need for research findings to be widely communicated, especially to stakeholders who can put them into practice on the ground.

The AfriCAN Climate project aims to support Africa in the process of adapting to and mitigating climate change, by bridging the gap between research and action. A dynamic web platform brings together an active network of European and African researchers and communication experts. In addition to disseminating information on climate change research and policy, the project facilitates the widespread sharing of indigenous knowledge and examples of good practice. The anticipated effect is an increased uptake of research results and their translation into practical projects that will have a direct impact on people's lives. The portal employed innovative and creative web functionalities to harmonise multilingual, interdisciplinary, and pan-continental climate change knowledge and to encourage project developers and stakeholders to learn and benefit from Africa's challenges and success stories. The AfriCAN Climate Portal targeted a wide variety of climate change stakeholders: researchers, field practitioners, project developers, development partners, NGOs, local/national governments, and farmers' organisations.

AfriCAN Climate users can be found in the 'People' section. Through internet news feeds and a newsletter, users receive regular updates on project progress, case studies, as well as information on the latest resources and financial opportunities. Online groups from various dissemination partnerships, facilitating knowledge sharing and maximising networking opportunities. Climate change knowledge related to scientific research, indigenous knowledge, and policies was collected in the form of articles, publications, news, project initiatives, organisational links, and networks. These knowledge resources are organised under the headings 'research' and 'policy'.

To help practitioners on the ground, case studies of good practices are show-cased by climate change experts. In order to assess the applicability and transferability of project interventions, case studies were evaluated against eight principles to assess their financial, economic, social and environmental sustainability. The AfriCAN Climate Portal provides climate change fact sheets for each African country in the most widely-spoken languages. The fact sheets provide information on the current and projected status of climate, natural resources, and agriculture.

10. The Moi University-OSSREA Hub of Climate Change, Disaster-Risk Reduction and Social Protection

The Organisation for Social Science Research in Eastern and Southern Africa (OSSREA), in collaboration with Moi University, Kenya, has

established a hub for climate change, disaster-risk reduction and social protection. This was the initiative of the author of this chapter, who was motivated by the fact that education is a key strategy identified under Agenda 21 in our efforts to achieve a more sustainable society. This educational agenda is supported by the UN Decade for Sustainable Development (2005-2014), the Hyogo Framework for Action (2005-2015), and Millennium Development Goal 2. All of them aim at integrating principles, values, and practices of sustainable development into all aspects of education and learning and to encourage changes in behavior that allow for a more sustainable and just society for all (UNESCO 2005). Agenda 21 and DESD international policy frameworks suggest education and sustainable development does not represent a single, new curriculum area for schools but rather a more integrated approach to providing appropriate education and training in a diverse and rapidly changing world.

The world is changing rapidly economically, ecologically, technologically, culturally; and in terms of population, international relations, social structures, etc. These changes result in increased tension between development and sustainability. In recent years, accelerating climate change has drawn increased attention to this tension. Warnings from scientists have increased and a mood of urgency marks the present situation. Should the educational system neglect this and continue as usual or should it respond to these challenges? How? Climate risks contain a degree of uncertainty, and addressing them requires being able to assess the interplay between a number of aspects, including ethical considerations of what is good and bad, rather than of solely aiming to uncover the truth. Furthermore, the balancing act between tackling long-term sustainable development issues and more immediate economic imperatives is another challenge for the education sector.

While the world has witnessed an exponential increase in human and material losses due to natural disasters, the frequency and intensity of extreme hydro-meteorological events due to climate change is higher (IPCC 2012). The effects of climate change and risks posed by increased degradation of the environment, deforestation, loss of biodiversity, reduced water supply and desertification, and poor land use practices exacerbate the situation. In addition to climate change, the main drivers of risk are poorly-planned and poorly-managed urbanisation, environmental degradation, poverty, and weak governance. Disaster-risk reduction should be part of the post-2015 development agenda in order to meet international development objectives (Mukuna and Manyasi 2015). Sustainable and integrated management of natural resources, including reforestation schemes, and proper land use and good management of rivers and coastal areas will increase the resilience of communities to disasters by reversing current trends of environmental degradation. Communities will have to adapt to stressful environmental conditions through disaster-risk reduction and resilience building measures. The risk of losing wealth in weather-related disasters is now outstripping the rate at which wealth is being created.

Economic development alone does not lower the level of vulnerability or risk, while damage from disasters in the context of climate change and unsustainable development threatens development gains, especially among the most vulnerable.

Africa, especially sub-Saharan Africa, is one of the most vulnerable continents to the anticipated climate change and variability impacts. On average, 25% of the GDP in Africa is derived from agriculture and 80% of the workforce is found in rural areas (UNDP 2013). In addition, most of Africa's exports originate from the agricultural sector. Yet, institutions that deal with climate change and its impact are few or non-existent in many countries. The adverse effects of climate change will confront Africa in a multi-faceted manner. It is reported that "climate change will cause a general decline in most of the subsistence crops" (UNFCCC 2007). Food security, exports, natural resources including water resources, health and livestock production have been and will be disrupted due to climate variability and change. Climatic hazards affect poor people the most, destroying homes and livelihoods and affecting their participation in the development process itself (UNDP 2013). Without adaptation strategies in place, these hazards lead to food and water shortages, population displacements, outbreaks of diseases, and general under-development.

Climate change education needs innovative, interdisciplinary, and competence-centred educators and learners. Given that DRR has been recognised as a key strategy of climate change adaptation (Save the Children 2008), there are clear linkages between many of the climate change adaptation activities. The concept of resilience has, therefore, become the lens through which we can view how aspects of natural and social systems interact to enable sustainability (Perring 2006). However, despite this recognition, resilience has attracted little attention in policy and practice at national and local levels, leave alone higher education institutions (Gaillard 2010, Nhamo 2014). It is important to note that developing resilience alone does not insulate sustainable development from disasters, but does reduce risk, and enables a swifter response and recovery, which will better secure development gains and protect lives.

10.1 Rationale

Integration of climate change (CC), disaster-risk reduction (DRR), and social protection (SP) interventions is a new field, but it is crucial for the proper adaptation and mitigation of climate change risks in developing countries. Climate change is a key priority for international development as its impact is likely to be disproportionately felt in developing countries. This is because developing countries are generally warmer, more prone to rainfall variability, and more dependent on agriculture. They also have the most climate-sensitive economic sectors, low income, and have limited risk-mitigation infrastructure – both physical and financial (e.g. insurance) (Stern 2007). Increased instances of drought, flooding, and severe weather events as well as incremental environmental change through processes such

as inundation, desertification, and salination are likely to exacerbate existing problems related to agricultural production, communicable diseases, migration streams, poverty, and conflict (Bangay and Blum 2010, Smith and Vivekananda 2007, UNICEF-UK 2008, WHO 2008).

Climate change, DRR, and social protection are not completely new concepts in education, but have developed their own identity and are at a nascent stage in the sub-Saharan education systems. These domains are embedded in environmental education, social studies, geography, science and life skills education. The missing link between policy and resilience is reflective of bigger missing links between knowledge generation and knowledge application. This factor motivated Moi University and OSSREA to develop a curriculum that will give climate change and its complexities a holistic, multi-disciplinary, and interdisciplinary approach. The curriculum is hoped to increase awareness on climate change, disaster-risk reduction, and social protection and build the capacity of actors to mainstream them in all sectors of development for an inclusive, transformed Africa. Both indigenous and scientific technology is integrated in all interventions, not only for the sustainability of programs but also to retain indigenous knowledge (Mercer *et al.* 2010). The Master's and PhD curricula for Integrated Climate Change, Disaster-Risk Reduction, and Social Protection are providing a framework to transfer disaster-risk reduction actions to climate change and social protection. This has been missing in sub-Saharan Africa for decades. This innovative curriculum is hoped to build resilience to climate change and disaster risks in the wake of regional climate-compatible development.

Climate change, disaster-risk reduction, and social protection are critical issues that merit intellectual attention and resources. However, very little seems to have been done in this area at the national and community levels. Most school curricula in sub-Saharan Africa, Kenya included, have not integrated these critical issues. First, there is lack of coordination of these multi-sectoral dimensions. Secondly, these three disciplines are taught under very many disjointed subjects. It is not known how best to integrate them into the curriculum, in which subject, mode, and at what level. There is no standard curriculum that has been developed to explicitly explore them. It is not clear which courses or subjects, which knowledge, what scope, depth, sequence and continuity would be appropriate to teach them. The mode of integrating the three disciplines of knowledge is not known; thus, it is not clear whether to make it a stand-alone subject or integrate the knowledge across the curriculum. The educators, policy makers, communities, and the civil societies do not seem to understand these emerging issues clearly. There is, therefore, a need for this integrated curriculum for capacity building among these actors to invoke debates that will create awareness on the three themes (Mukuna 2013).

Today, sub-Saharan Africa is faced with too many natural and man-made disasters, including road accidents and terrorism. The natural disasters are

exacerbated by climate change (IPCC 2007). This has been going on for decades without a safety-net program for the vulnerable communities in fragile ecological zones. Most countries have adopted a reactive, instead of a proactive, prevention and mitigation approach to disasters. Lack of education and capacity on climate change, disaster-risk reduction, and social protection is still haunting Africa. Despite the suffering that natural disasters bring to communities, destroying their livelihoods and drawing them further into poverty, Africa seems to learn her lessons slowly. Making our curriculum disaster-sensitive by integrating climate change, disaster-risk reduction, and social protection is the inoculation to this suffering (Mukuna 2013).

Climate change and disaster management have been perceived to be the work of humanitarian actors like the Red Cross, fire brigades, security forces, law enforcement agents, donor agencies, healthcare institutions, and researchers (Mercer 2010). Policies targeting the reduction of people's vulnerability to the impacts of climate change have not been mainstreamed in the public policies. Some African countries have made an attempt in this area with a national disaster-management policy, a national climate change adaptation strategy, a disaster-reduction policy for ASAL areas, an environmental policy, a flood-mitigation strategy, among others. All these policies have gaps of coordination and collaboration among partners. The linkage between climate change adaptation, disaster-risk reduction, and social protection does not come out clearly. This comprehensive integrated curriculum at the Moi University-OSSREA hub hopes to fill this lacuna in knowledge.

The school curriculum (formal and informal) has an important role to play in environmental sustainability and building resilience to impacts of disasters and climate change (Bonifacio *et al.* 2010). There is, however, an attempt to do this by some universities in Kenya such as Masinde Muliro University of Science and Technology (Disaster Management Program for post-graduate students); University of Nairobi (Disaster Management and Education in Emergencies); Kenyatta University (Integrated Watershed Management, Environmental Education and Climate Change for Sustainable Development). The Moi University-OSSREA hub has developed a comprehensive curriculum as a move towards inclusive and sustainable development.

At the moment, there is no university in Eastern and Southern Africa offering a postgraduate degree programme in integrated climate change, disaster-risk reduction, and social protection for sustainable development. This will go a long way in helping build the capacity of Africa as a whole to address integrated climate change, disaster-risk reduction, and social protection and sustainable-development-related issues in a holistic manner. This curriculum will enhance society's capability to understand, anticipate, and adapt to the impacts of climate change and variability and develop a better understanding of the relationships between adaptation, mitigation,

and development of the same. This will help improve human welfare and the environment through training, research, and outreach. Moi University also endeavours to establish a centre of excellence in climate change, disaster-risk reduction, and social-protection-related issues in the Eastern and Southern African regions as a whole. This will be achieved through education and research facilities aimed at generating leading policy-relevant research on integrated climate change, disaster-risk reduction, social protection, and their effects on sustainable development.

10.2 Objectives, Expected Learning Outcomes and Skills

The general objective of the postgraduate programmes in Integrated Climate Change, Disaster-Risk Reduction, and Social Protection is to cater for graduates who have a thorough understanding of resource utilisation, development, climate change, disaster and social-protection-related concepts. In addition, these people are capable of generating solutions to climate change, disaster, and development problems by linking climate change to disaster science, developmental issues, policies, and practices.

10.3 Specific Objectives

The specific objectives of the Master's and Ph.D. programmes in Integrated Climate Change, Disaster-Risk Reduction and Social Protection include:

- i. equipping graduates with a higher level of knowledge and enhanced understanding of the physical and human dimensions of climate change and disaster, allowing them to discharge effectively their duties within issues encountered by climate-disaster sensitive sectors such as agriculture, health, tourism, fisheries and wildlife;
- ii. producing graduates who can conduct research, training, advocacy, and community outreach in climate change, disaster, social protection and sustainable development issues;
- iii. equipping graduates with capacity for critical, empirical and analytical and writing skills to enable them to engage policy makers and package research findings in a manner that attracts research uptake and also write scholarly pieces out of their research work;
- iv. equipping graduates with the necessary multi- and inter-disciplinary knowledge and skills to fully understand, employ, and professionally engage in activities relating to climate change, disaster and social protection (e.g. climate science and modeling; analysis of climate change impacts; adaptation, mitigation and sustainable development in theory, practice and policy; climate change, disaster and social protection politics, governance, economics and law), to enhance the adaptive and mitigation capacity of the society to climate change and disaster, to address developmental concerns in their areas;
- v. tackling the chronic shortage of highly skilled and competent human resources who can provide services with high level competencies in governmental, non-governmental and private organisations on issues

relating to climate change, disaster, social protection and sustainable development; and

- vi. training graduates who can think critically and communicate effectively in the field of climate change, disaster, social protection and developmental issues.

10.4 Expected Learning Outcomes

The curriculum is designed with the view that graduates of the Master's and Ph.D. programmes in Integrated Climate Change, Disaster-Risk Reduction and Social Protection will be able to:

- i. provide leadership in local, national, regional and international development with a clear understanding of values and needs in the fields of climate change, disaster-risk reduction, social protection and sustainable development;
- ii. increase postgraduate numbers and new lecturers with expertise on CCA;
- iii. increase research capacity and interdisciplinary collaboration with a potential to inform decision-making and the overall policy process to alleviate poverty;
- iv. gain international recognition in research and training efforts;
- v. increase capacity to serve higher education clients and society at large;
- vi. apply geo-information in climate and disaster-risk management, particularly in drought, flood, and crop failure monitoring;
- vii. understand local views, perceptions, and practices of indigenous communities in relation to climate and disaster-induced shocks such as economic loss, hunger, famine, human dislocation and displacement; and understand climate change and disaster impacts, adaptation- and mitigation-related issues;
- viii. understand critically the connections between climate change and disaster science, policy, law, security and development;
- ix. effectively interrogate how policy and law geared to the environment can promote environmental protection, reduce climate change and disaster influences, and restore peace and tranquility in Kenya and beyond;
- x. conduct research on climate change and disaster science, climate, disaster and social protection economics, policy and law as well as sustainable-development-related issues;
- xi. understand regional climate systems, prediction, uncertainty and downscaling, and use of global circulation models in assessing climate change scenarios and disaster-risk reduction approaches;
- xii. identify, describe, and discuss the main theories and concepts in

- project design and management; and understand project, technical, financial, and economic analyses;
- xiii. analyse various circumstances, contexts, and reasons for occurrence of development and insecurity in a given locality and how to address them in the wake of climate change and disaster;
 - xiv. understand pollution abatement and quantitative methodologies for analysing energy, natural resources, and environmental problems; and, participate actively in community services in various capacities, such as environmental affairs. Students and Faculty across campuses will interact through exchanges and share academic and field work activities and this will increase the participation of HEI personnel in international fora on climate change (CC), and the development through this partnership and through ongoing projects will contribute to broadening perspectives and strengthening the intellectual capacity of all participants;
 - xv. increase visibility in the national arena where the HEI has a role to play in catalysing research into action for development; increase competitiveness of the HEI by providing top-quality training and research services to society at large. The emergence of novel networks and the strengthening of existing ones will allow for a cross-fertilisation of ideas across institutions and regions that could potentially transcend to the communities where each of these institutions work; and
 - xvi. increase networking capacity of the HEI, including enduring partnerships with the private sector.

10.5. Expected Skills

After the completion of the Master's and Ph.D. studies in Integrated Climate Change, Disaster-Risk Reduction and Social Protection degree programmes, graduates are expected to develop the negotiation skills, communication/ dissemination, presentation, critical thinking, project management, policy formulation and analysis, research and time management skills, changing research into development policy, integrating CCA, DRR and social protection into local development and resource use planning, and creative skills for structural change processes for improving people's welfare.

11. Conclusions

In this chapter I have presented five academic consortia and three regional economic communities and their work in Africa on climate change. This means that there is willingness and commitment to deal with the climate change challenge. It has emerged that the main driving force behind their establishment was lack of capacity by African scholars to deal with the climate change threat. This challenge has put most African countries at crossroads between development, mitigation, adaptation and development

of resilience to the impacts of climate change. Additionally, it is evident that African scholars are still challenged by lack of funding for cutting-edge research in climate change, lack of equipment and infrastructure in their home institutions, lack of quality supervision in climate change, lack of analytical capacity to publish in high quality peer-reviewed journals, lack of institutional and national strategies in climate change, among others. While this is true about Africa, higher education institutions have taken it in their stride to provide academic leadership in climate change adaptation and mitigation amidst rapid development. They endeavour to ensure that research done in higher education is translated into knowledge and information for communities and that the research uptake is implemented and policies that mainstream climate change are enacted and implemented.

It has also emerged that climate-compatible development is a new research paradigm. It is a multi-sectoral, inter-, intra- and multi-disciplinary discipline. It, therefore, brings on board various and diversified experts who work towards a common goal. For example, the CIRCLE project is focussing on capacity building and institutional strengthening of a critical mass of scholars in climate change for sustainable development. The SARUA project focuses on mapping climate-compatible development through universities. It focuses on capacity deficits and challenges, and suggests solutions to these problems. The PERI-PERI U project is focussing on disaster-risk reduction. Disasters destroy all the development achieved over a long period of time. A focus on mitigating or adapting to disasters will lead to development of resilience. As Africa rapidly develops economically, for her to sustain the economic growth, disaster-risk reduction is a must. It must also be mainstreamed in all development plans. The African Climate Portal project aims at demystifying climate change by removing barriers to communicating climate change. The last one is the Moi University-OSSREA hub on climate change, disaster-risk reduction, and social protection that has developed Master's and Ph.D. curricula in Integrated Climate Change, Disaster Risk Reduction and Social Protection. These, too, hope to build the capacity of African institutions in climate change and climate-compatible development. This broad spectrum of network is in the business of ensuring research uptake, sharing best practices, and identifying what does not work.

12. Lessons for Climate-Compatible Initiatives

- i. The five academic consortia state key climate vulnerabilities. They have a critical role to play in preparing society to adapt to the impacts of climate disruption by providing research and education around adaptation strategies and science.
- ii. They need to increase their curricular offerings on climate adaptation, both through mainstreaming the information in core courses and offering electives that specialise in the topic.

12. Lessons for Climate-Compatible Initiatives

- i. The five academic consortia state key climate vulnerabilities. They have a critical role to play in preparing society to adapt to the impacts of climate disruption by providing research and education around adaptation strategies and science.
- ii. They need to increase their curricular offerings on climate adaptation, both through mainstreaming the information in core courses and offering electives that specialise in the topic.
- iii. They face direct risks to their operations and infrastructure from the impacts of climate disruption.
- iv. They have the unique opportunity to role-model solutions in their own operations.
- v. They can serve as ‘hubs’ in their local communities for creating, testing, and disseminating knowledge about regional climate projections and adaptation strategies, and should work directly with their local communities to explain the science and implement solutions.
- vi. They should acknowledge the inequitable distribution of climate impacts across populations, with low-income communities and communities of colour being in most need.
- vii. They should aim to identify adaptation strategies that also contribute to mitigation efforts.
- viii. As a whole, they have not focused on adaptation sufficiently to date.

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CONCLUSION AND PERSPECTIVES

Chirstopher A. Shisanya

As the East African countries realise their development aspirations, there will be gains and risks. A growing population and economy with urbanisation will mean increases in greenhouse gas (GHG) emissions. The resultant environmental and social conditions, including increased competition over resources could intensify vulnerability to climate risks. Transitioning to a low-carbon climate-resilient development pathway can address future risks, thereby improving the region's ability to prosper under a changing climate while reducing the emissions intensity of a growing economy. **Low carbon development** is different from mitigation. Mitigation is about cutting emissions. Low carbon development reframes this challenge and argues that in some cases, the low carbon option is also the best development option for low income countries. Climate resilience and low carbon development can be combined into the term '**climate-compatible development**' as illustrated in Figure 12.1 (courtesy of CDKN). **Green growth** is an emerging concept that recognises that environmental protection is a driver of global and national economic development. It refocuses society on achieving qualitative growth rather than simply increasing GDP.

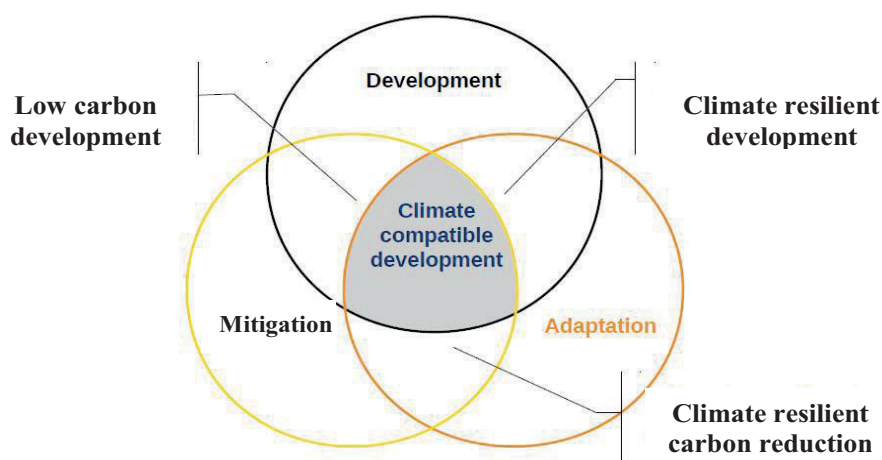


Fig. 1. Climate Compatible Development

SOURCE: www.cdkn.org.

The East African country's blue print visions set out development paths aimed at creating prosperous countries with a high quality of life and

encourage people-centred sustainable development — ensuring that climate change actions help the countries move towards long-term development goals. An integrated low-carbon climate-resilient pathway emphasises:

- ***Sustainable Development:*** Achieving sustainable development should be at the forefront of all climate actions; climate change and development are intricately linked.
- ***Adaptation:*** Reducing vulnerability to avoid or cushion the impacts of climate change, and enable people to respond to climate risks by moving toward a climate resilient society.
- ***Mitigation:*** Taking actions, where possible, to cut greenhouse gas emissions by departing from or modifying the business-as-usual practice; and to reduce the human causes of emissions by moving toward a resource-efficient economy that is as low carbon as possible.

For the East African region, the conundrum of choosing between action on climate change and action on development is a false one; the two are interlinked and will become increasingly so over the coming decades. Building climate resilience or increasing the ability to adapt to climate change, by using as low carbon as possible, will help the region to achieve sustainable development and country-specific goals. A low carbon climate resilient development pathway should be tailored to the country's unique circumstances.

Low carbon climate resilient development can bring benefits, including:

- ***Enhancing Sustainable Development:*** The best low carbon climate resilient opportunities deliver multiple benefits, helping to address pressures related to increasing population growth, economic growth, urbanisation and resource use. Low carbon resilient development enhances the integration of the social, economic and environmental pillars of sustainable development. As outlined by the International Labour Organisation (2012), the transition to a low carbon climate resilient development pathway can include a shift to green jobs—where the economy, companies and workplaces promote decent work that:
 - reduces consumption of energy and raw materials;
 - limits GHG emissions;
 - minimises waste and pollution; and
 - protects and restores ecosystems.
- ***Improving Lives of the Poor and Vulnerable:*** The human impacts of climate change are often experienced most acutely by the poor, who are often women and children. The urban poor living in slums that are flood-prone and the rural poor who rely on ground water for water supply and rainfall for food production are particularly vulnerable.

Efforts to improve climate resilience can further the effectiveness of the region's people-centred development strategy.

- **Building Adaptive Capacity:** The East African region's vulnerability to climate change is influenced by the adaptive capacity of its people and institutions, or their ability to take advantage of opportunities or to cope with the consequences of potential damages. Improving development outcomes such as income, literacy, social networks and access to information and services is critical to building the region's adaptive capacity.
- **Reducing Disaster Risks:** The use of climate risk information in economic activities (such as farming), public infrastructure investment and government planning decisions can enhance decision-making capacity, and reduce and prevent climate-related disasters and climate risks.
- **Attracting International Climate Finance, Technology and Capacity Building:** Potential sources of international support include: bilateral and multilateral funders, the Green Climate Fund, the Adaptation Fund, carbon markets, and the emerging Nationally Appropriate Mitigation Actions (NAMAs) and REDD + mechanisms.
- **Leveraging Investment:** A coherent action plan can encourage investment in low carbon climate resilient technologies and industries, such as water resource management, renewable energy, and agroforestry. Policy and institutional reforms supported through climate finance can stimulate investment in targeted actions that support a low carbon climate resilient pathway.

A low carbon climate resilient development pathway is a promising option for the East Africa region to meet its development goals, while increasing ability to manage climate risk. The drivers of the region's economies are primarily natural resource-based and climate-sensitive and new investments in infrastructure must consider expected changes in temperature and precipitation. The region can advance economic growth in ways that reduce climate risk or are less carbon-intensive while seizing opportunities for innovation, such as leapfrogging to the best-available technology. Making the right investments now can prevent technology lock-in and a more costly transition in the future. This development pathway can help to improve competitiveness through a focus on the sustainable use of resources, improved productivity, and decreased vulnerability to variations in climate.

Challenges will have to be addressed in implementing low carbon climate resilient interventions; but many of these can be addressed through a systematic focus to identify and remove barriers. These efforts can be supported through international climate mechanisms and other international support. Finance, technology and capacity building support can help fill information and capacity gaps and overcome financial, regulatory and policy barriers.

Some of the priority action plans for the East Africa region could include, but not limited to the following:

- sustainable intensification of small-scale farming;
- agricultural diversity of markets;
- sustainable land use management;
- integrated water resources management;
- low carbon energy grid;
- small/scale energy access in rural areas;
- disaster management and disease prevention;
- green industry and private sector development;
- climate compatible mining;
- resilient transport systems;
- low carbon urban systems;
- ecotourism conservation and payment for ecosystem services;
- sustainable forestry, agroforestry and biomass; and
- climate data and projections.

The East Africa region must navigate towards a ‘safe operating space’ that provides adequate food and nutrition security for everyone while boosting robust economic growth and without crossing critical environmental thresholds. Charting a course towards this space will require climate compatible innovative technologies, policies and institutions that will guarantee resilience to the impacts of current and future changes to the climate regime. While change will have significant costs, the implications of remaining on a business-as-usual path are already enormous and growing. Given the already intolerable conditions of many livelihoods and ecosystems, and the time lag between research and development and widespread application, action must be taken now.

Whereas this anthology presents empirical and exemplar evidence on climate-compatible development in the region, the greater challenge is with up-scaling even the replicable ones. Scoping an implementation plan that would encapsulate the building of competencies within the region to routinely undertake the implied tasks and accomplish expected outcomes is critical. It will be crucial to the accomplishment of the objectives and targets of climate compatible development in the region. Based on what have been presented in this anthology, I commend the implementation of climate compatible development based on principles of adaptive management and participatory engagement as the central tenets of the overall implementation strategy. Adaptive management acknowledges uncertainty as a context of decision-making and builds flexibility into policy and decision-making to manage risk and it allows for new

knowledge input. This is important because climate compatible development investments are capital-intensive and long-lived. Building climate change considerations into the design of these investments is, therefore, necessary even with some degree of uncertainty in climate projections. Decisions made in other sectors almost always have a positive or detrimental impact on the ability of the natural environment to adapt. It is important that climate compatible developments take into account the role of the natural environment and develop solutions that are in harmony with nature.

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It is widely recognised that climate change poses significant serious threats to sustained economic growth and agricultural development, poverty reduction, food security and political stability globally. Nowhere are these challenges more marked than in Africa where two-thirds of all available land is classified either as desert or dry land, in relation to which the Intergovernmental Panel on Climate Change (IPCC) (2013) has classified the continent as the most vulnerable to climate change variability. This anthology is a product of a call from OSSREA to collate evidence based researches in a book in a bid to assess how far countries in eastern and southern Africa are implementing the UNFCCC, Rio+20, Agenda 21 and other global and Africa-wide decisions concerning the need to address climate change. This will contribute to post-2015 development agenda for sustainable development goals (SDGs), in which climate change and disaster risk reduction will be priority areas of focus. We hope this book will serve as a valuable tool for experts, advisers and policymakers in pursuing effective green growth policies and practices and achieving climate compatible development and in doing so inspire readers to choose a more sustainable pathway for humanity. It will also help in looking at climate change as both a challenge and opportunity for development. Further, this book aims at stimulating more research in climate compatible development and climate financing which have put most countries at crossroads.

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